APPENDIX E

1999 BASE CASE DEVELOPMENT AND PERFORMANCE ANALYSES

AACOG
Alamo Area Council
Of Governments

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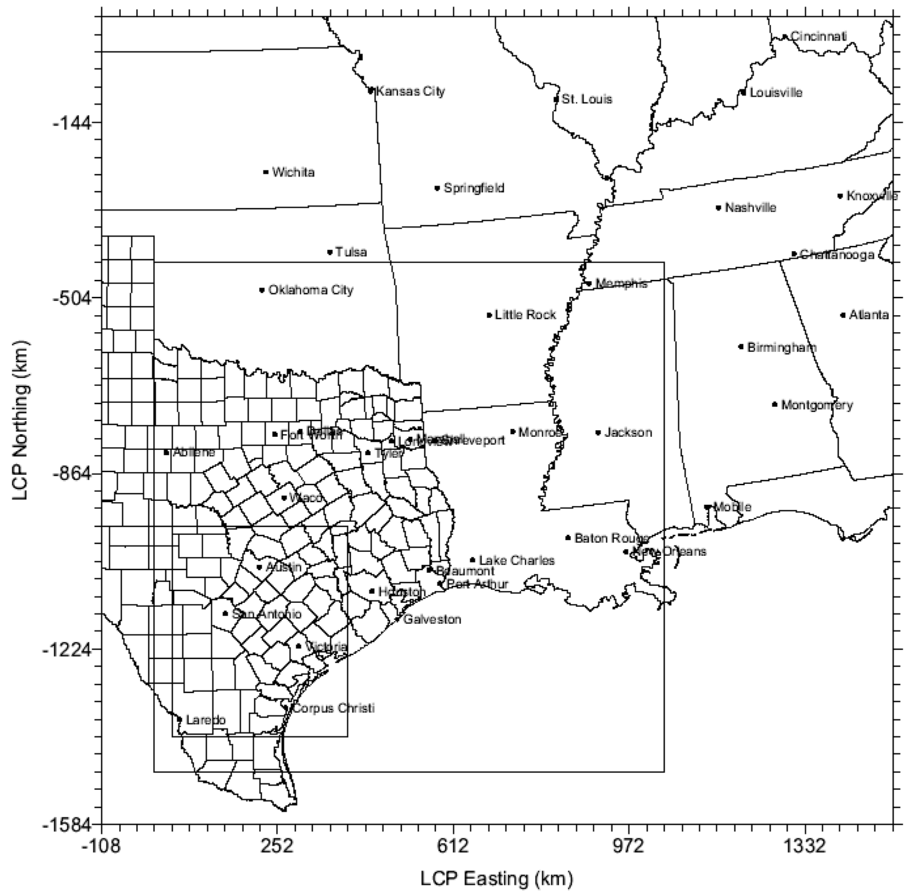
INTRODUCTION

The elevated ozone episode that occurred between September 15 – 20, 1999 in South-central Texas was modeled using the Comprehensive Air quality Model with extensions (CAMx). This is an alternative model for developing air quality simulations in accordance with EPA's (On-line, no date) report, Summary Descriptions of Alternative Air Quality Models. CAMx is a Eulerian photochemical grid model that makes use of a two-way nested grid structure, with the coarsest grid (36-km) covering a wide regional domain, a 12-km grid that incorporates Eastern Texas including the nonattainment areas of Dallas/Fort Worth, Houston/Galveston, and Beaumont/Port Arthur, and a fine grid (4-km) extending over four Texas near nonattainment areas as shown in figure E-1.

Figure: E-1. Nested Grid System for the 1999 South Texas Photochemical Model Simulation.



CAMx Grid Dimensions

LCP Grid with reference origin at (40 N, 100 W)

36 km Grid: 45 x 46 cells from (-108, -1584) to (1512, 72)
12 km Grid: 87 x 87 cells from (0, -1476) to (1044, -432)
4 km Grid: 90 x 108 cells from (36, -1404) to (396, -972)

(nested grid dimensions do not include buffer cells)

The original September 1999 simulation was developed by ENVIRON International Corporation and documented in their report *Development of a Joint CAMx Photochemical Modeling Database for the Four Southern Texas Near Non-Attainment Areas* (Emery, Tai, Wilson, and Yarwood, 2002). Their final and best performing run (developed without arbitrary meteorological or emissions inputs), labeled CAMx Run 13, produced promising results. However, CAMx Run 13 exhibited some problems that were prevalent in earlier simulations, including consistent under-predictions of maximum and mean ozone concentrations. ENVIRON staff recommended performing comprehensive QA/QC procedures on model settings and inputs, particularly meteorological and emissions inputs, and incorporating refinements to the model where appropriate.

ENVIRON and the University of Texas at Austin conducted extensive analyses of the meteorological model used as CAMx input for the September 1999 episode. Development of the original meteorological model, labeled Met 3c, was described in ENVIRON's report (Emery et al., 2002). As a product of the QA/QC analyses conducted by the ENVIRON/UT team, numerous improvements were made to the meteorological model. Some revised runs, including Met 6f and Met 5d, attenuated, although not necessarily eliminated, certain problems associated with Met 3c, including over-prediction of wind speeds at night and under predictions during the daytime and over prediction of early morning temperatures. Most of the refinements the ENVIRON/UT team incorporated into the meteorological model are documented in the report *Revised Meteorological Modeling of the September 13-20, 1999 Texas Ozone Episode* (Emery, Tai, McGaughey, and Allen, 2003). Development of the meteorological model used as input to the final photochemical model run, labeled Met 5g, is described in appendix B of the SAER SIP revision.

Emissions inputs were also reviewed and refined for the September 1999 baseline simulation. One of the most significant refinements made to the 1999 modeling EI was use of MOBILE6 to estimate on-road emissions for some urban counties in Texas. MOBILE6 was not available when the original September 1999 model was created. Texas Transportation Institute, under contract with the TCEQ, recalculated on-road files for 18 NNA counties, including Bexar County, using the newly-released MOBILE6 model. The original MOBILE6 file, referred to as version 1, was later refined to incorporate an improved methodology to account for heavy-duty diesel vehicle VMT. The refined MOBILE6 on-road file for the 18 NNA counties is labeled version 2. (See Appendix C for a detailed description of TTI's on-road estimation methodology.) In addition to enhanced mobile on-road estimations, the State provided AACOG with refined EIs for specific geographic locations including other NNA areas (Austin, Corpus Christi and Victoria), Houston, and the remainder of the State of Texas.[1]

AACOG was also provided a refined point source file (TCEQ 2003), which contained additional VOC emissions for Houston, to account for the results of a study conducted as part of the TexAQS 2000 project. However, staff decided to omit the revised Houston point source file in the final 1999 baseline simulation for several reasons. First, a sensitivity run (CAMx Run 17c) in which the file was included as model input indicated

[1] The updated Texas EI was developed for the 2000 Houston attainment SIP and includes refined area and non-road emission estimations. Since the Houston EI was developed for a different time period, the emissions were backcast to September 1999 using projection ratios developed from EGAS and NONROAD models.

the increased VOC emissions for Houston point sources had an insignificant impact on ozone concentrations in San Antonio during the September 1999 episode. Second, as of the timeframe when the final baseline run (CAMx Run 18) was developed and tested, the State had yet to receive approval from the EPA to use the modified point source file in the Houston attainment demonstration SIP. Third, the refined VOC database did not include a 2007 projection. Using the refined data for only the 1999 base case would create inconsistencies in the treatment of the base case and projection case EIs. And fourth, the modified EI was designed for a 2000 episode, not 1999.

Table E-1 provides a description of the meteorological and emissions inputs to the final set of sensitivity and baseline runs conducted for the September episode beginning with the first 1999 base case submitted by ENVIRON, CAMx Run 13, through development of the final baseline run, CAMx Run 18.

MODEL INPUTS

Methodologies used to develop the major inputs to the photochemical model are described in detail in appendix B *Development of the 1999 Meteorological Model*, Appendix C *On-Road Mobile Emissions Inventory Development*, and appendix *D 1999 Base Case Modeling Emissions Inventory Development* of the SAER attainment demonstration SIP. This appendix focuses on development of other inputs to the model simulation and selection of CAMx model options. The following sections on development/determination of land use data, dry deposition algorithms, chemistry data, boundary/initial conditions, and CAMx model options were provided by The University of Texas at Austin and ENVIRON (September 17, 2003) in their draft report *Development of the September 13-20, 1999 Base Case Photochemical Model for Austin's Early Action Compact.* Except where noted, these sections focus on model inputs and options for the final baseline run, CAMx Run 18.

Land Use Data

ENVIRON (Jimenez et al., 2002) developed land use grid data to characterize surface boundary conditions for the September 1999 episode. This information was developed from the same data used to generate spatial emission surrogates. ENVIRON created software to process the raw spatial surrogate data into the eleven land use categories used by CAMx, to grid the data to the 36, 12, and 4km CAMx grids, and to write the results in an appropriate format for input to CAMx.

Dry Deposition Algorithms

Dry deposition algorithms in CAMx are based on the regional-scale deposition model developed by Wesely et al. (1989). These algorithms have been widely used in both field applications and air quality models.

ENVIRON and UT reviewed the Palmer drought severity index, shown in figure E-2 for eastern Texas and found a moderate level of drought stress during the episode. Although the MM5 models accounted for reduced soil moisture, the original dry deposition algorithm in the September 13-20, 1999 CAMx model did not account for vegetation moisture stress. Because of the potential influence of drought stress on the uptake of pollutants through plant stomata and the importance of dry deposition as a

Table E-1. Meteorological and Emissions Inputs to CAMx Photochemical Model Test Runs.

CAMx Run:	Run 13	Run 13b	Run 13c	Run 13d	Run 13e	Run 14	Run 15	Run 16	Run 17	Run 17b	Run 17c	Run 17d	Run 18
Met 3c	✔	✔	✔	✔	✔								
Met 3c + Increased Mixing layer				✔									
Mer 6f								✔					
Met 5d						✔	✔						
Met 5g									✔	✔	✔	✔	✔
Updated Texas EI										✔	✔	✔	✔
Updated Austin EI										✔	✔	✔	✔
Updated 2007 Regional EI*													✔
Updated Victoria's EI													✔
BC/IC 60		✔			✔		✔		✔	✔		✔	✔
Mobile5	✔	✔	✔	✔	✔	✔	✔	✔					
Mobile6 version 1									✔	✔	✔		
Mobile6 version 1x1.4**												✔	
Mobile6 version 2 (VMT Upgrade)													✔
Modified dry deposition			✔		✔		✔		✔	✔		✔	✔
Additional VOC from Houston's Point Sources											✔		

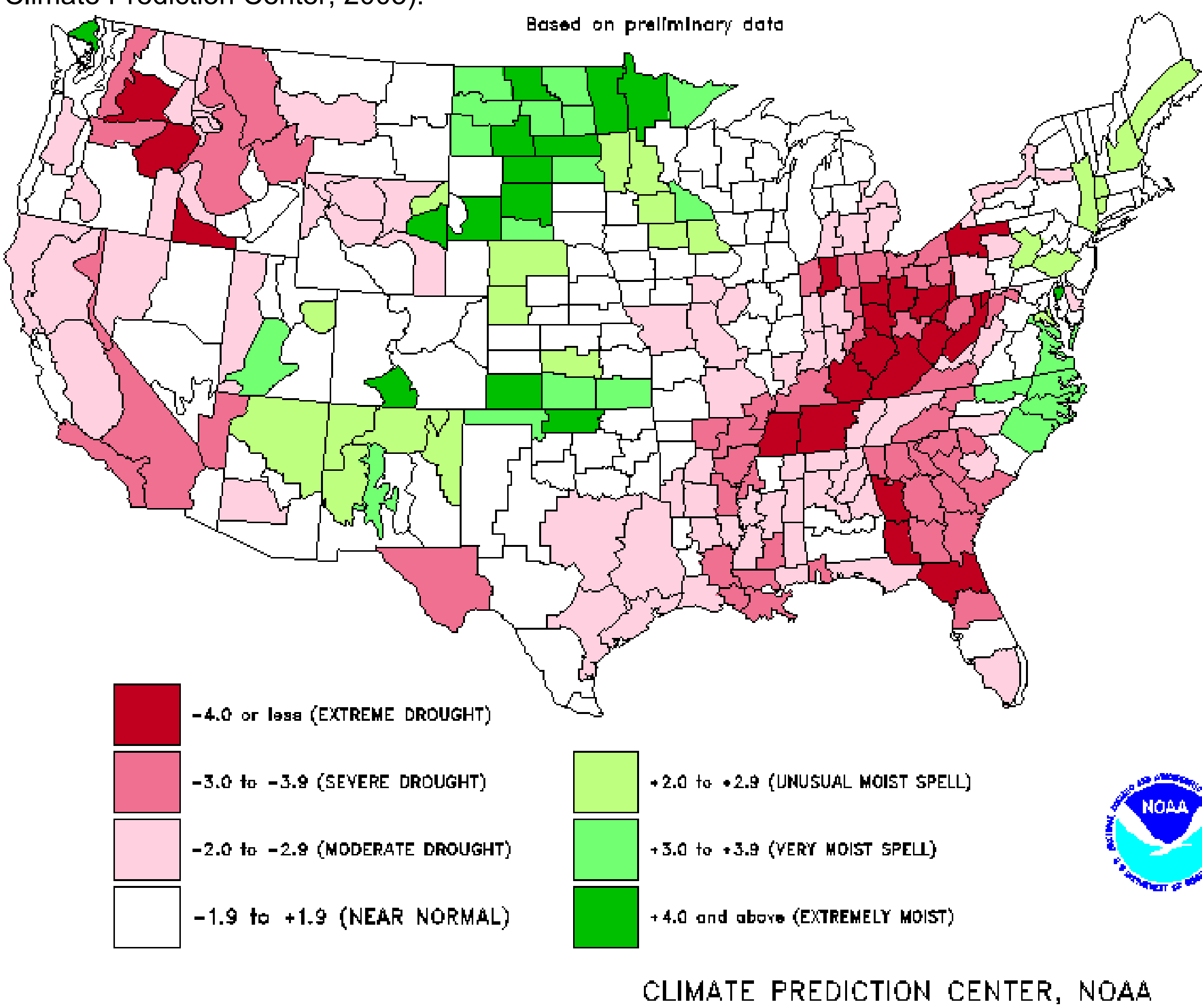
*The Austin, Corpus Christi, San Antonio, and Victoria portions of the August 2000 Texas EI were removed from the model and replaced with refined area-specific September 1999 emissions for those areas. For the remainder of the State, the August 2000 Texas EI was backcast to September 1999.

**Version 1x1.4 is a sensitivity run conducted prior to receiving the MOBILE6 version 2 EI file. It was employed to test the anticipated impact of increasing HDD VMT (Version 2) by multiplying HDD VMT by 1.4 (increasing HDD VMT by 40%).

physical removal process for ozone and other secondary pollutants, ENVIRON initiated changes to the CAMx deposition algorithms for the September 13-20, 1999 episode.

Wesely supplies minimum bulk stomatal resistances by season and land use type. High resistances (9999) represent no deposition through the stomata. Vegetation moisture stress codes (0=unstressed; 1=stressed, 2=extremely stressed) essentially define The current formulation of Wesely's dry deposition model in CAMx can be manipulated to account for drought stress through the use of vegetation moisture stress codes. Factors by which minimum bulk stomatal resistances are increased/decreased to reflect drought conditions: if istress =1 then the stomatal resistance is increased by a factor of two; if istress = 2, then the stomatal resistance is increased by a factor of 10. ENVIRON increased drought stress codes over land use categories by one to reflect summer drought conditions for those land use categories that did not already have very high minimum bulk stomatal resistances. With the approval of the TCEQ and the U.S. EPA, these modifications were adopted by San Antonio and Austin for the September 13-20, 1999 photochemical model.

Figure E-2. Long-term Palmer Drought Severity Index for September 18, 1999 (NOAA Climate Prediction Center, 2003).



Chemistry Data
Chemistry data, developed by ENVIRON (Emery *et al.*, 2002) for the September 1999 episode, are summarized in Table E-2.

Table E-2. Summary of Chemistry Data for the September 13-20, 1999 CAMx Model.

Input Data/Specification	Description
Chemistry Parameters	CB4 with current radical termination reactions and isoprene mechanism
Photolysis rates	TUV version 4
Albedo/Haze/Ozone File	• Surface UV albedo from land use grid data • Total ozone column data from satellite data from the Total Ozone Mapping Spectrometer (TOMS) • Haze optical depth field assumed spatially and temporally constant at 0.1.

Boundary and Initial Conditions
A number of sensitivity studies focusing on boundary and initial conditions were conducted following the initial CAMx model performance evaluation of the September 13-20, 1999 episode. The results of the model performance evaluation and CAMx simulations conducted by ENVIRON suggested that the September 1999 episode was promising, but required additional refinement to improve performance. Daily peak and daily mean ozone concentrations were under predicted by 10-20% and 10-30%, respectively, at each ambient monitoring site. Although the unpaired peak accuracy and normalized gross error met EPA criteria on most days, the relative bias failed to meet EPA criteria in all near non-attainment areas on at least one episode day.

EPA default boundary and initial conditions, which were used in the original modeling, are shown in the last column of Table E-3. AACOG initiated sensitivity studies that focused on increasing ozone concentrations from 40 ppb to 60 ppb along all boundaries of the 36-km domain and in the initial conditions supplied to CAMx. Model performance improved significantly and indeed, EPA performance criteria for unpaired peak accuracy, normalized bias, and gross error, were met on most days in Central Texas. The AACOG and the University of Texas, on behalf of CAPCO, then undertook a number of sensitivity studies to further elucidate the influence of boundary and initial conditions on model performance:

- Increase all boundary conditions to 60 ppb
- Increase ozone concentrations along the northern and eastern boundaries from 40 ppb to 60 ppb.
- Increase ozone concentrations along the northern boundary from 40 ppb to 60 ppb.
- Increase ozone concentrations along the eastern boundary from 40 ppb to 60 ppb.
- Increase initial ozone concentrations from 40 ppb to 60 ppb.

In conjunction with the sensitivity studies, UT also examined whether the increase in ozone concentrations upwind and along the boundaries could be supported by ambient monitoring data during the episode. UT developed time series from relevant U.S. EPA AIRS monitors as well as from the IMPROVE network. In total, data from sixteen states (Oklahoma, Kansas, Nebraska, Missouri, Iowa, Indiana, Illinois, Arkansas, West Virginia, Ohio, Kentucky, Tennessee, North Carolina, Georgia, South Carolina, Alabama) were examined. Although the sensitivity studies led to variable degrees of improvement in model performance, the ambient data did not support increasing ozone concentrations above 40 ppb along most boundaries throughout the episode. The exception was the area of domain that encompassed Tennessee and North Carolina, which experienced ozone concentrations in excess of 60 ppb on most episode days.

The TCEQ suggested that UT examine the effects of boundary and initial conditions used for the September 1993 photochemical model for Houston's State Implementation Plan on model performance. These boundary and initial conditions are currently being used for the August 13-22, 1999 episode for the Dallas/Fort Worth area, for the Longview/Tyler/Marshall area, and for Oklahoma (Yarwood, 2003).

All of the model applications described above suffered from a tendency to underpredict regional ozone levels, which prompted a review of the boundary conditions. In particular, total VOC levels of only 4.4 ppb may be too low in areas of the regional modeling domain that are over land. Boundary condition values shown in Columns 1-3 of Table E-3 were originally developed for the TCEQ's regional modeling of the September 1993 episode (Yocke *et al.*, 1996). These values varied by boundary segment, as shown in Figure E-3 and were based on several data sources. Concentrations along the East/Northeastern Boundary were based on EPA's guidance for UAM modeling (EPA, 1991) with CO reduced from 350 ppb to 200 ppb and higher biogenic VOCs (ISOP, MEOH and ETOH) based on measurements at Kinterbish, AL for the Rural Oxidants in the Southern Environment study (Goldan *et al.*, 1995). Western boundary concentrations were based on EPA's UAM modeling guidance (EPA, 1991) with CO reduced from 350 ppb to 200 ppb and were consistent with data from Niwot Ridge, CO (Watkins *et al.*, 1995). Southern Boundary concentrations were based on the GMAQS (Gulf of Mexico Air Quality Study) sponsored by the Minerals Management Service (MMS, 1995). Initial conditions were identical to those in Column 3.

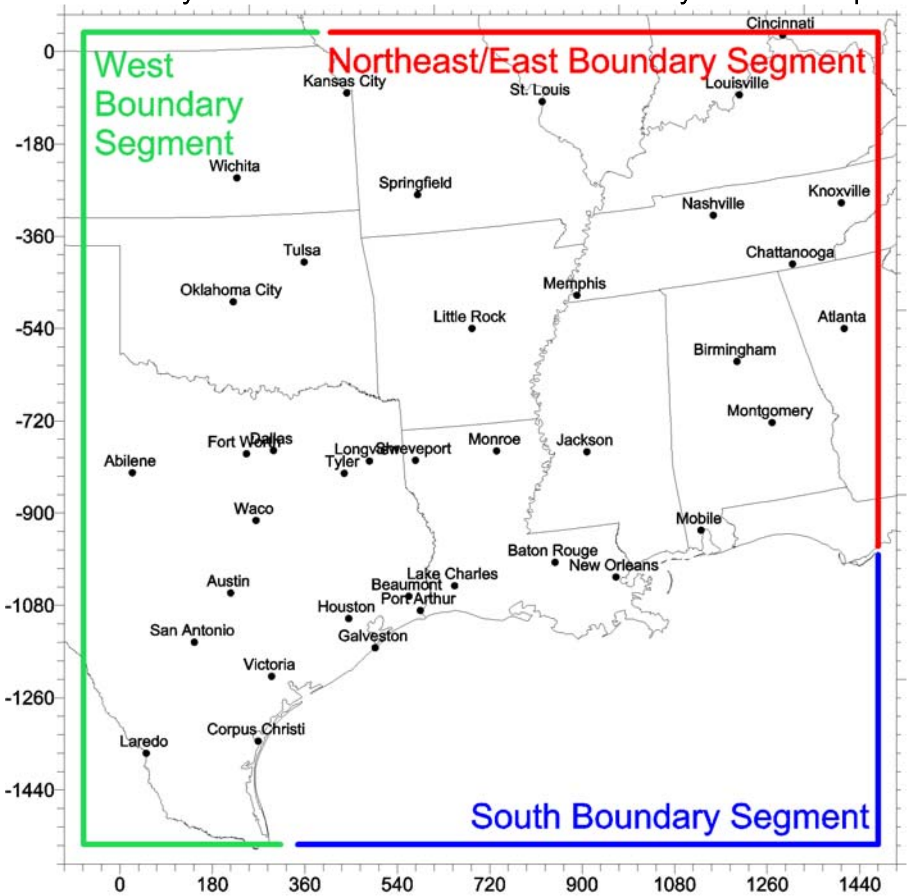
UT conducted a sensitivity study using the September 1993 Houston/Galveston boundary and initial conditions and found improved model performance for the September 13-20, 1999 episode in Central Texas. The negative bias predicted by the original model was considerably reduced, and this metric, now fell within the range of EPA performance criteria. Model performance statistics will be described in detail below, but improved ozone predictions were observed throughout the regional domain, including in the Houston/Galveston area. Because of the significantly improved model performance and the robust technical basis of these data, Austin and San Antonio, in collaboration with the TCEQ, decided to use these boundary and initial conditions for the photochemical modeling for their Early Action Compacts.

Table E-3. Boundary and Initial Conditions used by in the Original Model and the Final Model used by San Antonio and Austin for their Early Action Compacts. (Initial conditions were identical to concentrations along the western boundary. The EAC boundary and initial conditions are identical to those used in the September 1993 Houston/Galveston model for the State Implementation Plan.)

Species	NE Boundary below 1700m (ppb) *(EAC)*	West Boundary below 1700 m (ppb) *(EAC)*	SE Boundary and Above 1700m (ppb) *(EAC)*	Default Initial and Boundary Conditions used in original modeling*.
O_3	40	40	40	40
CO	200	200	100	100
NO	0.1	0.1	0.1	0.000049
NO_2	1	1	1	0.08555
HNO_3	3	3	1	1.525
HNO_2	0.001	0.001	0.001	0.000728
ALD2	0.555	0.555	0.05	0.1051
ETH	0.51	0.51	0.15	0.005315
HCHO	2.1	2.1	0.05	1.068
OLE	0.3	0.3	0.05	
PAR	14.9	14.9	7.6	3.078
TOL	0.18	0.18	0.0786	0.006043
XYL	0.0975	0.0975	0.0688	
ISOP	3.6	0.1	0.001	
PAN	0.1	0.1	0.1	0.03834
H_2O_2	3	3	1	2.263
MEOH	8.5	0.001	0.001	
ETOH	1.1	0.001	0.001	

*EPA Guidance

Figure E-3. Map Showing the Delineation of Boundary Segments for the Photochemical Model used by Austin and San Antonio for their Early Action Compacts.*



*below 1700 m

CAMx Model Options

CAMx model options, established by ENVIRON (Emery et al., 2002), are summarized in Table E-4.

Table E-4. Summary of Options for the September 13-20, 1999 CAMx Model.

Input Data/Specification	Description
Advection Scheme	Piece Parabolic Method (PPM)
Plume-in-Grid Model	Selected for major NOx sources $\geq$10 tons/day in 4 km grid > 25 tons/day in 12- and 36-km grids
Chemical Mechanism	CMC fast solver

SEPTEMBER 13-20, 1999 PHOTOCHEMICAL MODEL PERFORMANCE

Performance analyses were conducted on several versions of the baseline runs as a means of comparing the results of refinements made to the model. EPA recommends various types of performance tests in their 8-hour guidance: graphics, ozone metrics, precursor concentrations, observational models, weekend/weekday comparisons, ratios of indicator species, and retrospective analyses. Analyses using observational models, ratios of indicator species, and retrospective studies were not conducted on the 1999 model, due to a lack of necessary data & tools.

For example, the use of observational models is suggested in cases where an extensive monitoring network exists and precursor and indicator species are measured using instruments with appropriate sensitivity (EPA, 1999). During the September 1999 time period, just three regulatory ozone monitors were operational in the entire San Antonio EAC region. Also, there were no (e.g., SO2) species being measured in the region. The sole ozone precursor monitored by San Antonio area CAMS stations was NOx: CAMS 27 located in downtown San Antonio, CAMS 59 located at Calaveras Lake in southeastern Bexar County, and CAMS 62 located northeast of San Antonio in Caldwell County. However, the NOx levels were employed for precursor concentration analyses, provided in section 3.6.3 of the Executive Summary; all other performance evaluations are provided in the sections that follow.

Model performance was evaluated using statistical and graphical metrics in accordance with EPA guidance (1999) for both 1-hour and 8-hour attainment demonstrations. The following sections provide the results of the 1-hour and 8-hour performance tests conducted on the final September 1999 base case, CAMx Run 18.

During the September 1999 episode, peak ozone concentrations in the SAER were measured at CAMS 23 and 58. Therefore, metrics results for these monitors are of particular interest. Because of their importance, all statistics (1-hour and 8-hour) for CAMS 23 and CAMS 58 are included in this appendix. Some test results (1-hour time series plots and 8-hour scatter and Q-Q plots) for other monitors within the 4-km subdomain were omitted from this appendix for the sake of brevity. These tests/results will be provided to the EPA and the TCEQ on compact disc with submission of this SIP revision.

Model Performance: 1-Hour Averaged Ozone Concentrations
EPA recommends conducting a series of 1-hour graphical performance procedures and statistical performance tests as part of the performance evaluation process (EPA 1991). When evaluating statistical test results, monitoring network density should be considered. Since, individually, the San Antonio and Austin area networks are sparse, statistical measurements were conducted on groups as well as individual monitors.

Ozone Metrics
The 1-hour statistics were determined using a program developed by ENVIRON: “camxpost.” This program calculates unpaired peak accuracy (UPA), average paired peak accuracy (APPA), peak timing bias (PTB), normalized bias (NB), fractional bias, normalized error (NE), and fractional error (FE). Statistical metrics and associated EPA performance criteria for 1-hour averaged ozone concentrations include

Statistical Performance Measure	Performance Criteria
Unpaired highest prediction accuracy	±20%
Normalized bias	±15%
Gross error of all pairs > 60 ppb	+35%
Average paired peak accuracy	--
Bias in peak timing	--

The results of the camxpost program are presented for each monitor and for groups of monitors (averages for Austin monitors, San Antonio monitors, and the eight Central Texas monitors) within the 4-km subdomain in tables E-5 through E-17. Yellow-highlighted values in these tables represent statistics that fall outside EPA's performance criteria on primary episode days (September 15 – 20, 1999). While it is not necessary to conduct these tests on model initialization days (September 13-14, 1999), statistics for the initialization period are included for comparison purposes. Model initialization statistics that fall outside performance thresholds are listed in bold type. Columns where data are missing represent days in which predicted measurements were less than 60 ppb.

The 1-hour statistical results are also provided in graphic form for some monitors. Figures E-4 through E-21 present bar graphs of 1-hour statistics for CAMS 23, CAMS 58, and the averaged data for eight Central Texas monitors. Monitor numbers, monitor locations, and descriptions of monitor groups are as follows:

CAMS #	Monitor Name/ Group Name	Location	AIRS #
3	Murchison	Travis County	48-453-0014
4	Corpus Christi West	Nueces County	48-355-0025
21	Corpus Christi Tuloso	Nueces County	48-355-0026
23	San Antonio Northwest	Bexar County	48-029-0032
38	Audubon	Travis County	48-453-0020
58	Camp Bullis	Bexar County	48-029-0052
59	Calaveras Lake	Bexar County	48-029-0059
62	San Marcos	Caldwell County	48-055-0062
87	Victoria	Victoria County	48-469-0003
601	Fayette	Fayette County	48-149-0001
678	CPS Pecan Valley	Bexar County	48-029-0055
3, 38	Austin Monitors	Travis County	
23, 58, 59, 678	San Antonio Monitors	Bexar County	
3, 23, 38, 58, 59, 62, 601, 678	Central Texas Monitors	Bexar, Caldwell, Fayette, Travis	

Performance statistics for the San Antonio area monitors were quite good overall, although the statistical results for CAMS 59 tended to exhibit a negative bias. Unpaired peak accuracy was also somewhat problematic, particularly at CAMS 678. When results of all four San Antonio monitors were averaged (table E-12), all daily 1-hour statistical measurements fell within acceptable bounds with the exception of unpaired peak accuracy on September 19th.

Normalized bias was also a performance issue for the Austin area. Furthermore, when 1-hour results for the two Austin monitoring locations were averaged, the problem only improved slightly. One-hour statistics for the coastal areas, Corpus Christi and Victoria, exhibited a similar negative bias.

Table E-15 provides statistical metrics for 1-hour averaged ozone concentrations in Central Texas, which includes results for the Austin, San Antonio, San Marcos, and Fayette County monitors. As demonstrated, model performance met EPA acceptance criteria for each day of the primary episode.

Table E-5. 1-hour Statistics for CAMS 3, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	N/A	21.1%	13.1%	5.2%	5.1%	4.8%	3.2%
APPA	N/A	N/A	1.5%	-5.0%	-9.3%	-3.9%	-1.7%	-28.5%
PTB	N/A	N/A	-1	0	0	1	2	1
NB	N/A	N/A	1.2%	-7.5%	15.0%	-10.9%	-5.2%	-23.7%
FB	N/A	N/A	1.1%	-7.9%	-16.5%	-12.2%	-5.8%	-28.5%
NE	N/A	N/A	4.2%	7.5%	15.0%	11.4%	10.2%	23.7%
FE	N/A	N/A	4.1%	7.9%	16.5%	12.7%	10.6%	28.5%

Table E-6. 1-hour Statistics for CAMS 38, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	12.4%	13.8%	-16.9%	-5.4%	15.0%	-3.8%	26.8%
APPA	N/A	-9.1%	-7.2%	-20.5%	-12.0%	-25.6%	8.9%	22.0%
PTB	N/A	-1	-1	-2	1	1	1	-10
NB	N/A	-7.1%	-7.1%	-12.8%	-15.8%	-19.4%	-15.8%	-19.4%
FB	N/A	-7.4%	-7.6%	-13.8%	-18.0%	-22.1%	-17.7%	-22.1%
NE	N/A	7.1%	8.1%	12.8%	16.3%	19.4%	15.8%	19.4%
FE	N/A	7.4%	8.5%	13.8%	18.4%	22.1%	17.7%	22.1%

Table E-7. 1-hour Statistics for Austin Monitors (CAMS 3 & 38), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	12.4%	13.8%	-16.9%	-5.4%	-15.0%	-3.8%	3.2%
APPA	N/A	-9.1%	-2.8%	-12.7%	-10.6%	-14.7%	-5.3%	-25.2%
PTB	N/A	-1	-1	-1	1	1	2	-6
NB	N/A	-7.1%	-4.2%	-10.5%	-15.5%	-15.7%	-11.0%	-21.3%
FB	N/A	-7.4%	-4.5%	-11.3%	-17.4%	-17.8%	-12.4%	-24.8%
NE	N/A	7.1%	6.7%	10.5%	15.8%	15.9%	13.3%	21.3%
FE	N/A	7.4%	7.0%	11.3%	17.7%	18.0%	14.6%	24.8%

Table E-8. 1-hour Statistics for CAMS 23, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	1.3%	7.9%	9.0%	2.6%	15.0%	8.7%	26.3%	6.7%
APPA	-16.7%	-12.5%	-9.9%	-16.7%	-5.3%	3.9%	-3.2%	-0.3%
PTB	-1	0	-1	-3	2	1	-2	-3
NB	**-20.7%**	-14.3%	-12.6%	-21.2%	-11.0%	-3.2%	-5.7%	6.8%
FB	-23.6%	-15.5%	-13.7%	-24.5%	-11.8%	-3.7%	-6.0%	4.6%
NE	20.7%	14.3%	12.6%	21.2%	11.0%	6.7%	6.7%	19.8%
FE	23.6%	15.5%	13.7%	24.5%	11.8%	7.1%	7.0%	19.2%

Table E-9. 1-hour Statistics for CAMS 58, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	5.7%	**20.8%**	14.0%	15.0%	15.0%	2.6%	23.6%	13.1%
APPA	-12.9%	-4.2%	-16.1%	-2.7%	0.6%	-12.3%	20.1%	-9.6%
PTB	-3	-3	-4	-2	1	0	0	-4
NB	**-24.5%**	-6.2%	-9.9%	-7.9%	0.9%	-10.4%	4.8%	2.1%
FB	-28.0%	-6.7%	-10.5%	-8.7%	0.8%	-11.0%	4.2%	0.8%
NE	24.5%	6.8%	9.9%	10.2%	4.7%	10.4%	9.0%	14.4%
FE	28.0%	7.3%	10.5%	11.0%	4.7%	11.0%	8.6%	14.5%

Table E-10. 1-hour Statistics for CAMS 59, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-8.8%	14.2%	9.9%	1.4%	5.4%	32.0%	23.6%	16.6%
APPA	-20.7%	-20.5%	-27.3%	-13.8%	-17.8%	-21.1%	-17.6%	2.6%
PTB	1	-3	2	5	7	2	1	-2
NB	**-23.3%**	**-19.3%**	-16.8%	-10.2%	-10.6%	-18.5%	-14.4%	-16.6%
FB	-26.5%	-21.4%	-18.8%	-11.3%	-11.6%	-20.6%	-15.7%	-20.1%
NE	23.3%	19.3%	16.8%	12.5%	11.3%	18.5%	15.4%	18.0%
FE	26.5%	21.4%	18.8%	13.6%	12.3%	20.6%	16.8%	21.4%

Table E-11. 1-hour Statistics for CAMS 678, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-1.0%	**25.3%**	27.0%	14.1%	33.5%	32.0%	30.4%	5.7%
APPA	-7.9%	-10.2%	-11.3%	-13.0%	-1.0%	-7.9%	-4.6%	-10.1%
PTB	1	-1	1	-2	1	3	-1	-1
NB	-8.2%	-12.2%	-9.6%	-7.0%	1.6%	-6.2%	-5.7%	-4.5%
FB	-8.7%	-13.0%	-10.2%	-7.6%	1.6%	-6.7%	-5.9%	-4.8%
NE	8.2%	12.2%	9.6%	8.2%	2.7%	6.5%	5.7%	6.1%
FE	8.7%	13.0%	10.2%	8.7%	2.6%	7.0%	5.9%	6.4%

Table E-12. 1-hour Statistics for San Antonio Monitors (CAMS 23, 58, 59 & 678), September 13 – 20, 1999.San Antonio Monitors

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-8.8%	7.9%	9.0%	2.6%	5.4%	2.6%	23.6%	5.7%
APPA	-14.6%	-11.9%	-16.1%	-11.5%	-5.9%	-9.4%	-1.3%	-4.3%
PTB	-1	-2	-1	-1	3	2	-1	-3
NB	**-19.8%**	-12.9%	-12.9%	-11.5%	-5.6%	-10.2%	-5.7%	-4.0%
FB	-22.4%	-14.1%	-14.1%	-12.9%	-6.1%	-11.1%	-6.4%	-6.0%
NE	19.8%	13.1%	12.9%	13.0%	8.0%	11.0%	9.6%	14.9%
FE	22.4%	14.3%	14.1%	14.4%	8.5%	11.9%	10.0%	15.9%

Table E-13. 1-hour Statistics for CAMS 62, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	N/A	21.1%	15.4%	7.7%	19.2%	22.9%	30.1%
APPA	N/A	N/A	-9.2%	5.3%	-14.6%	-11.6%	-3.5%	1.2%
PTB	N/A	N/A	0	1	5	-11	-1	0
NB	N/A	N/A	-4.5%	4.9%	-10.0%	-11.6%	-6.5%	2.6%
FB	N/A	N/A	-4.7%	4.5%	-11.4%	-12.5%	-6.9%	2.6%
NE	N/A	N/A	6.3%	6.5%	14.2%	11.6%	7.6%	3.3%
FE	N/A	N/A	6.5%	6.3%	15.3%	12.5%	8.0%	3.2%

Table E-14. 1-hour Statistics for CAMS 601, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-4.5%	N/A	9.3%	29.5%	-6.1%	3.6%	13.8%	24.4%
APPA	-18.7%	N/A	-5.5%	2.0%	-14.4%	-10.5%	-5.7%	4.0%
PTB	-1	N/A	-1	-3	2	-1	-2	3
NB	**-18.5%**	N/A	-3.8%	-0.9%	-17.6%	-11.8%	-12.5%	-5.8%
FB	-20.3%	N/A	-4.1%	-1.2%	-19.7%	-12.9%	-14.5%	-6.8%
NE	18.5%	N/A	5.2%	6.7%	17.6%	11.9%	16.4%	10.5%
FE	20.3%	N/A	5.4%	6.7%	19.7%	13.0%	18.1%	11.3%

Table E-15. 1-hour Statistics for Central Texas Monitors (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-8.8%	7.9%	-9.0%	-16.9%	-5.4%	-15.0%	-3.8%	5.7%
APPA	-15.4%	-11.3%	-10.6%	-8.0%	-9.2%	-11.1%	-3.1%	-7.8%
PTB	-1	-2	-1	-1	2	-1	0	-2
NB	**-19.5%**	-11.7%	-8.5%	-8.2%	-11.0%	-12.1%	-8.5%	-9.1%
FB	-22.0%	-12.7%	-9.2%	-9.2%	-12.3%	-13.4%	-9.6%	-11.2%
NE	19.5%	11.9%	9.5%	11.0%	12.7%	12.5%	11.7%	14.9%
FE	22.0%	12.9%	10.2%	11.8%	13.9%	13.8%	12.5%	16.6%

Table E-16. 1-hour Statistics for Corpus Christi (CAMS 4 & 21), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	13.0%	-11.9%	-0.9%	2.7%	-1.5%	6.9%	9.6%	-0.7%
APPA	-31.8%	-24.7%	24.9%	-18.6%	-15.2%	-3.1%	4.9%	-15.0%
PTB	-1	-2	0	-6	-4	-2	3	2
NB	**-29.4%**	**-23.6%**	-21.5%	-23.0%	-21.7%	-14.3%	-8.3%	-25.4%
FB	-35.5%	-27.2%	-24.2%	-26.1%	-24.7%	-16.7%	-10.5%	-31.4%
NE	29.4%	23.6%	21.5%	23.0%	21.7%	15.6%	16.2%	25.4%
FE	35.5%	27.2%	24.2%	26.1%	24.7%	18.0%	17.9%	31.4%

Table E-17. 1-hour Statistics for CAMS 87, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-13.8%	1.9%	8.4%	6.2%	3.0%	0.7%	-0.5%	-16.8%
APPA	-44.8%	18.5%	-17.3%	-3.5%	-6.6%	15.1%	-3.9%	-20.4%
PTB	0	-6	-1	-2	-1	1	-3	1
NB	**-31.5%**	-13.3%	-7.6%	-3.7%	-9.7%	-21.5%	-18.7%	-20.0%
FB	-37.8%	-14.4%	-8.2%	-4.0%	-10.8%	-24.6%	-24.4%	-23.3%
NE	31.5%	13.3%	11.2%	5.3%	10.4%	21.5%	20.0%	20.0%
FE	**37.8%**	14.4%	11.9%	5.5%	11.5%	24.6%	25.6%	23.3%

Figure E-4. 1-hour Unpaired Peak Accuracy, CAMS 23, September 13 – 20, 1999.

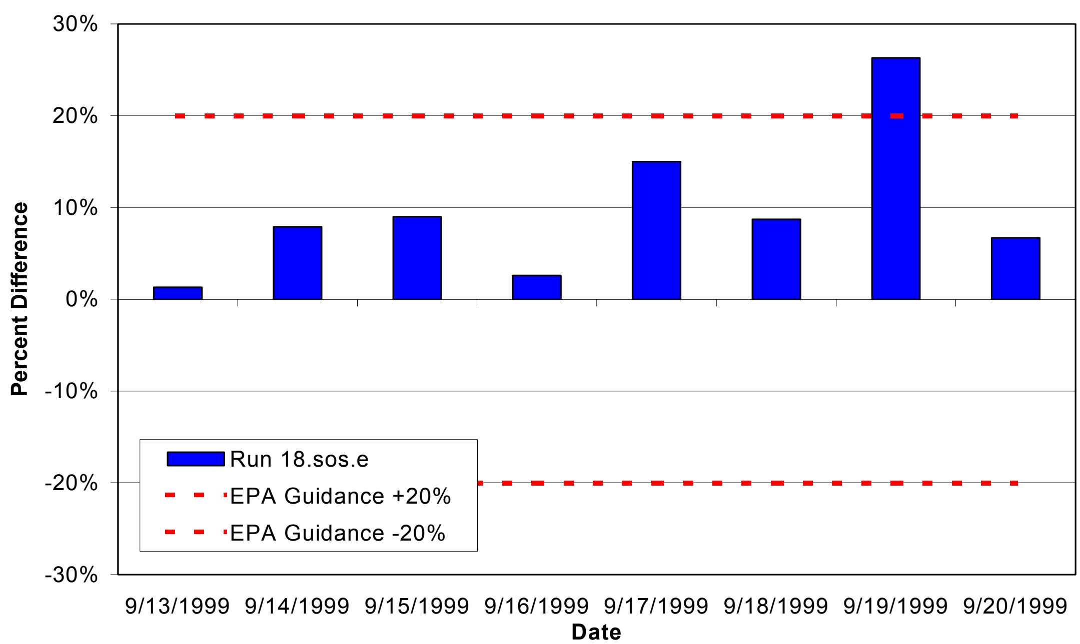


Figure E-5. 1-hour Unpaired Peak Accuracy, CAMS 58, September 13 – 20, 1999.

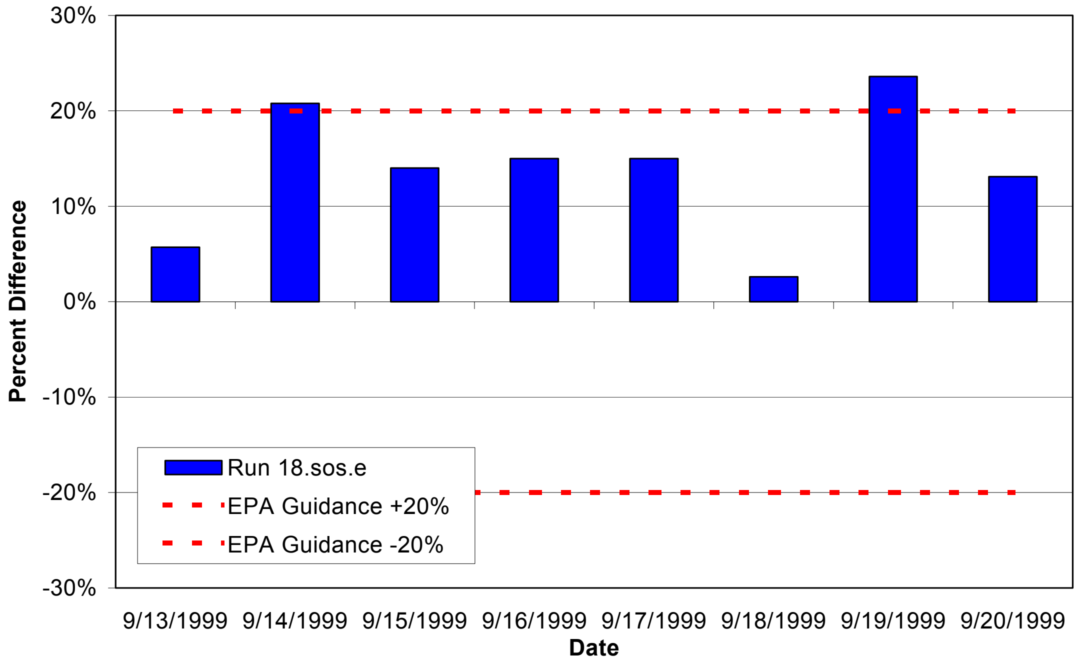


Figure E-6. 1-hour Unpaired Peak Accuracy, Central Texas Monitors (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.

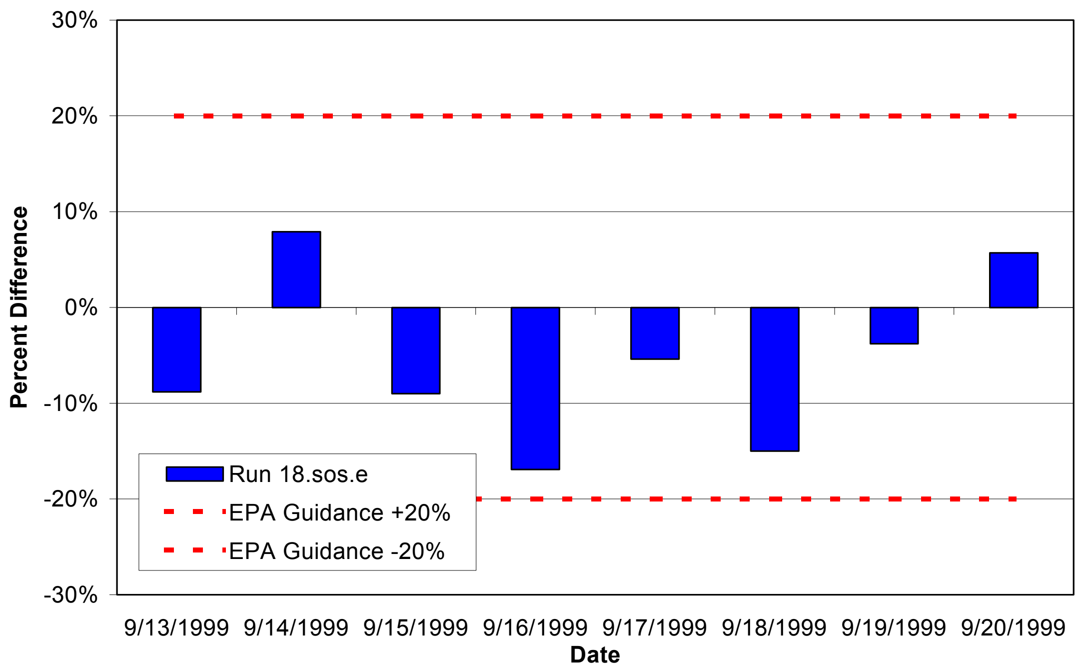


Figure E-7. 1-hour Average Paired Peak Accuracy at CAMS 23, September 13-20, 1999.

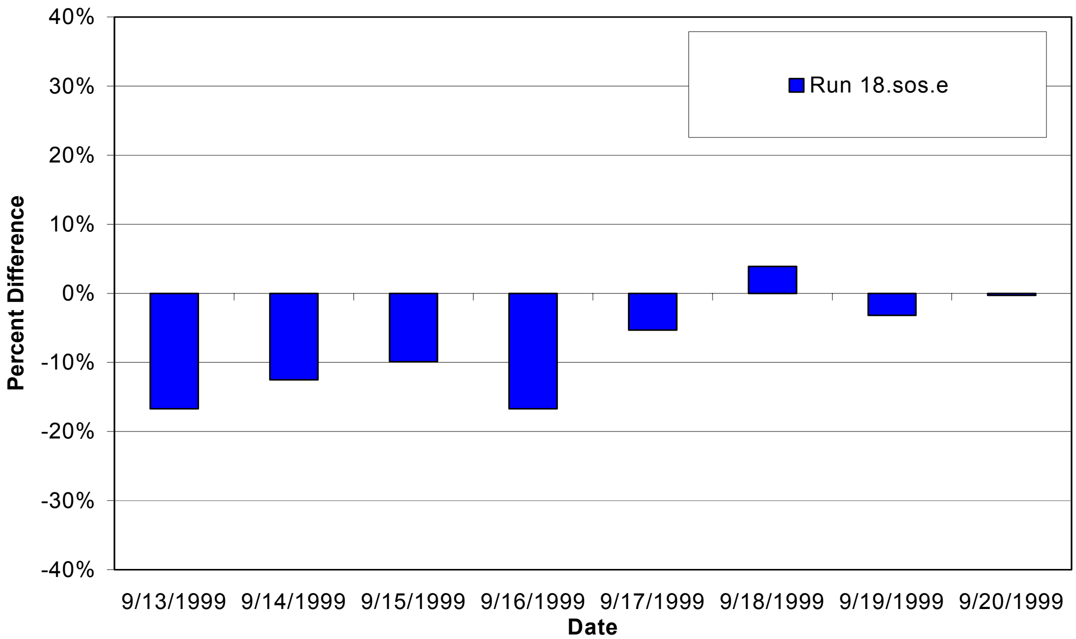


Figure E-8. 1-hour Average Paired Peak Accuracy at CAMS 58, September 13-20, 1999.

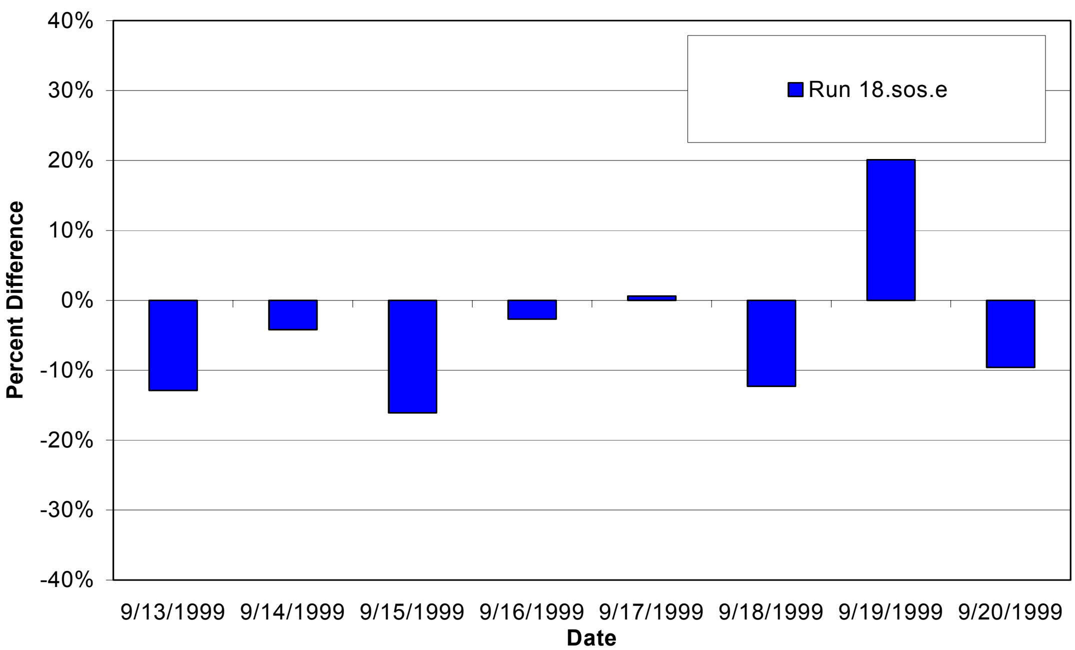


Figure E-9. 1-hour Average Paired Peak Accuracy at Central Texas Monitors (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13-20, 1999.

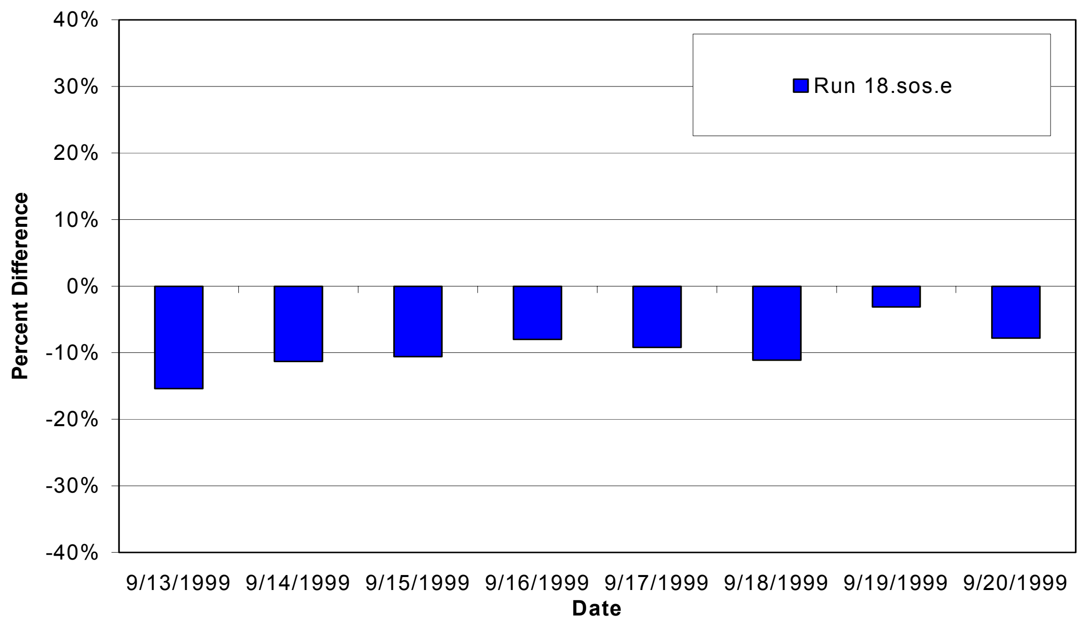


Figure E-10. 1-hour Normalized Bias at CAMS 23, September 13 – 20, 1999.

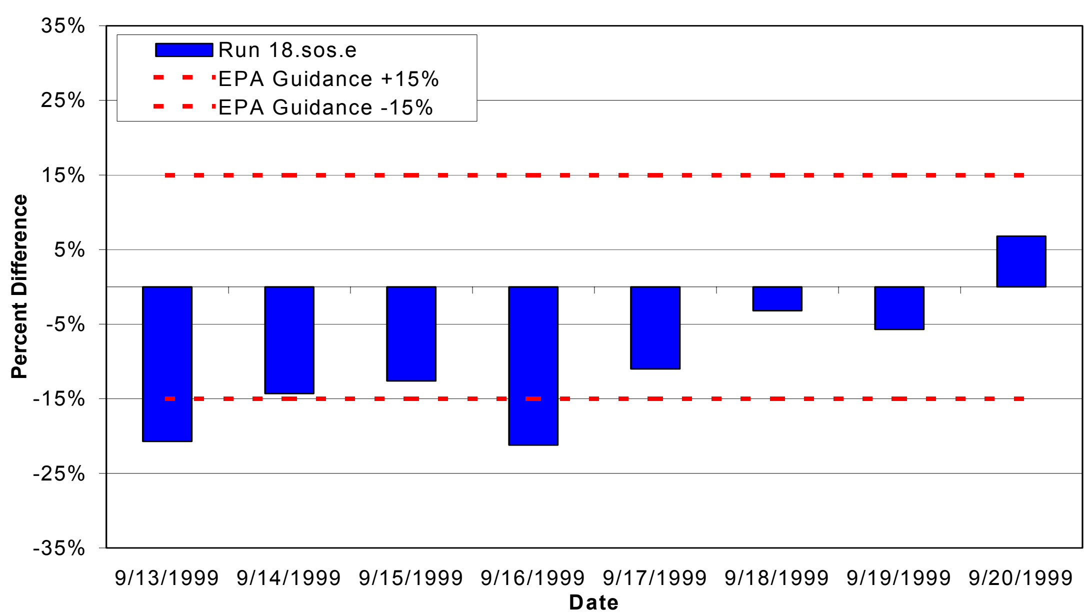


Figure E-11. 1-hour Normalized Bias at CAMS 58, September 13 – 20, 1999.

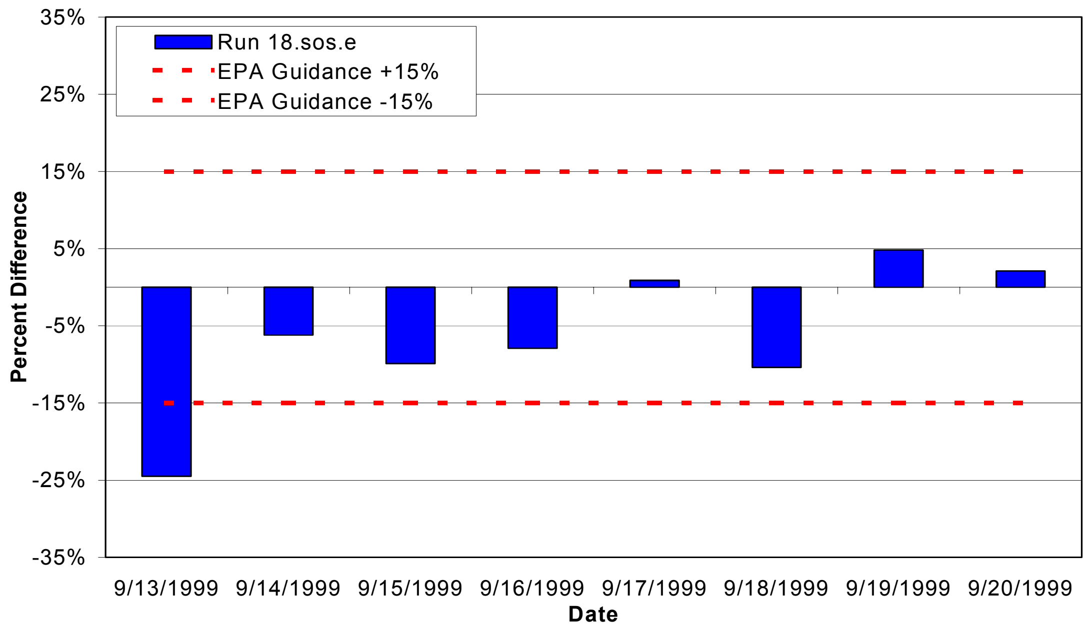


Figure E-12. 1-hour Normalized Bias at Central Texas Monitors (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.

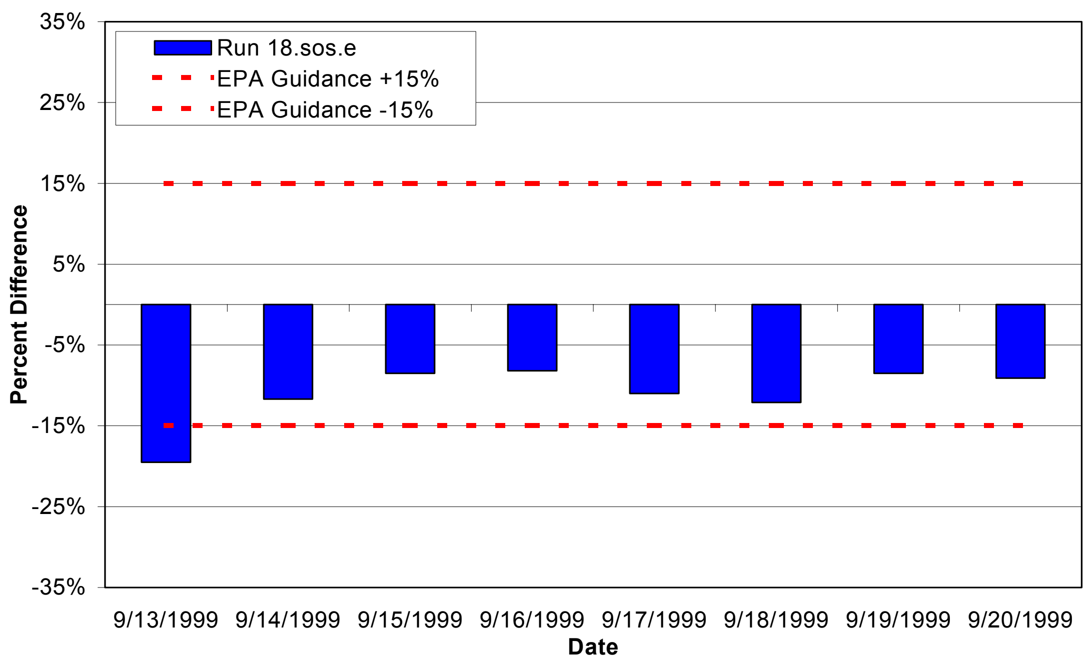


Figure E-13. 1-hour Normalized Error at CAMS 23, September 13 – 20, 1999.

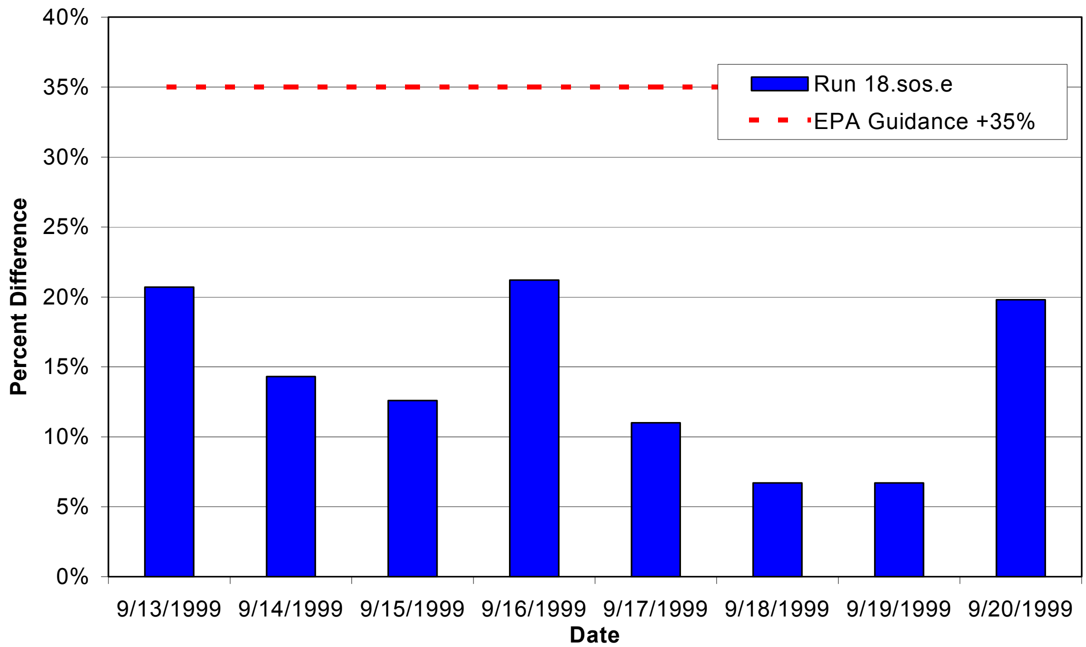


Figure E-14. 1-hour Normalized Error at CAMS 58, September 13 – 20, 1999.

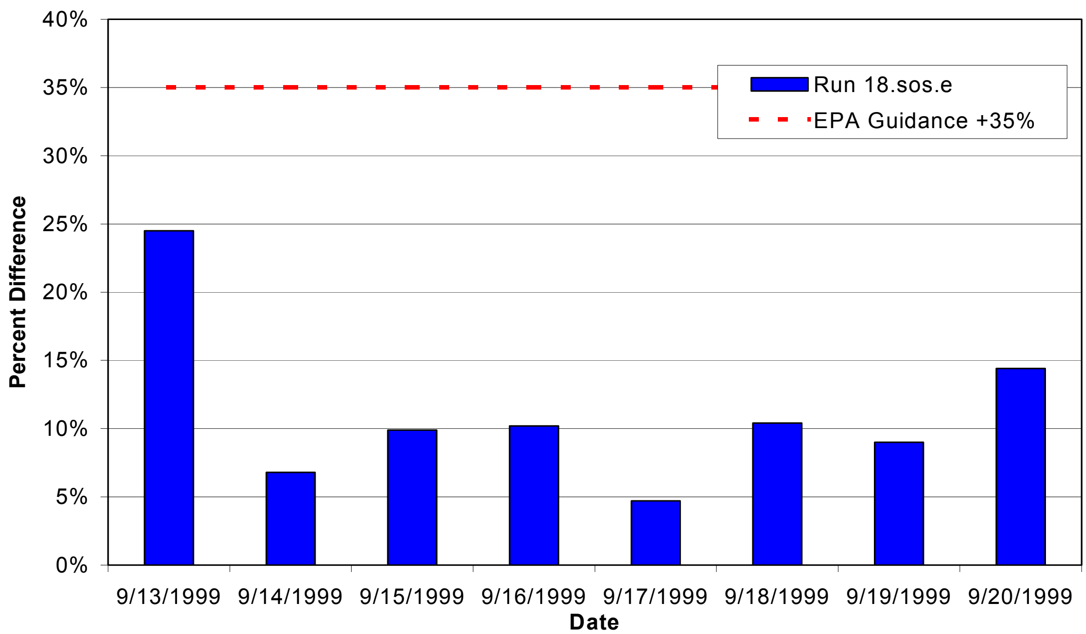


Figure E-15. 1-hour Normalized Error at Central Texas Monitors (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.

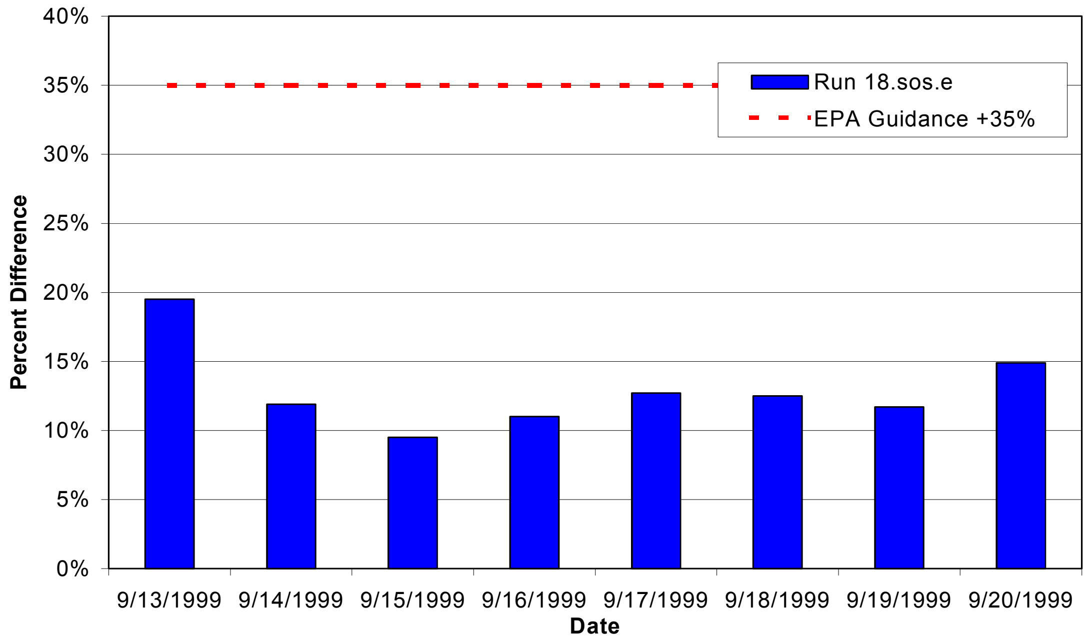


Figure E-16. 1-hour Timing Bias at CAMS 23, September 13 – 20, 1999.

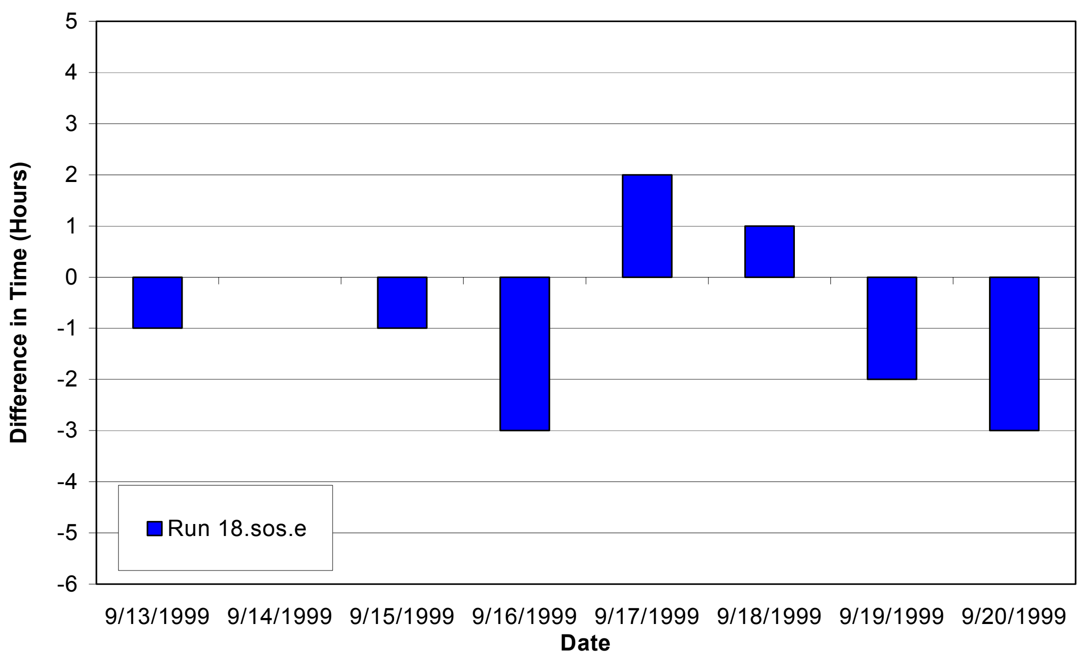


Figure E-17. 1-hour Timing Bias at CAMS 58, September 13 – 20, 1999.

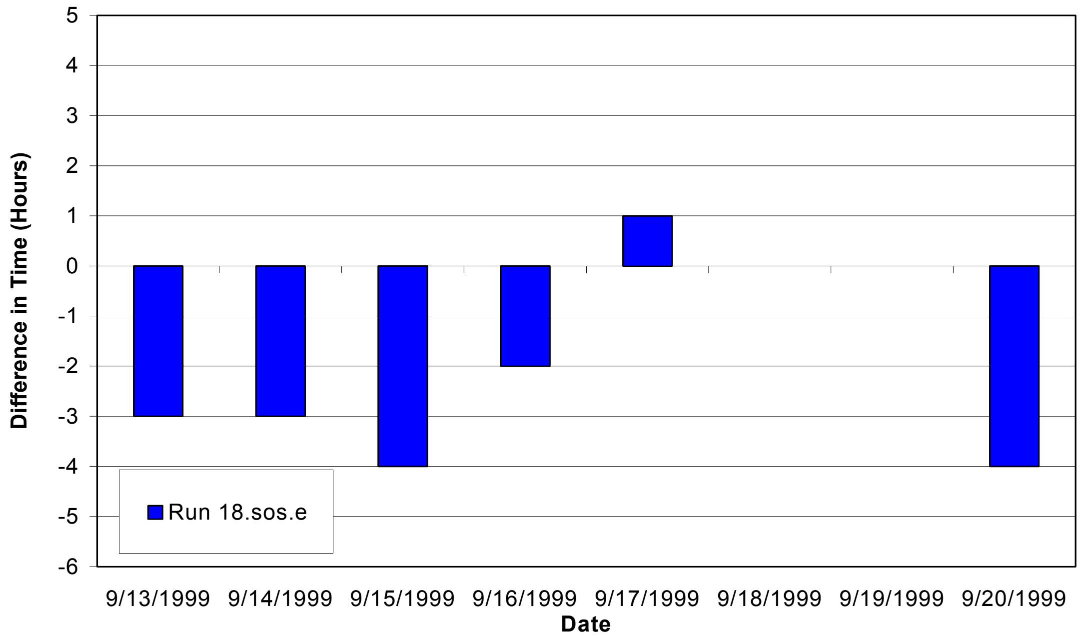


Figure E-18. 1-hour Timing Bias at Central Texas Monitors 23 (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.

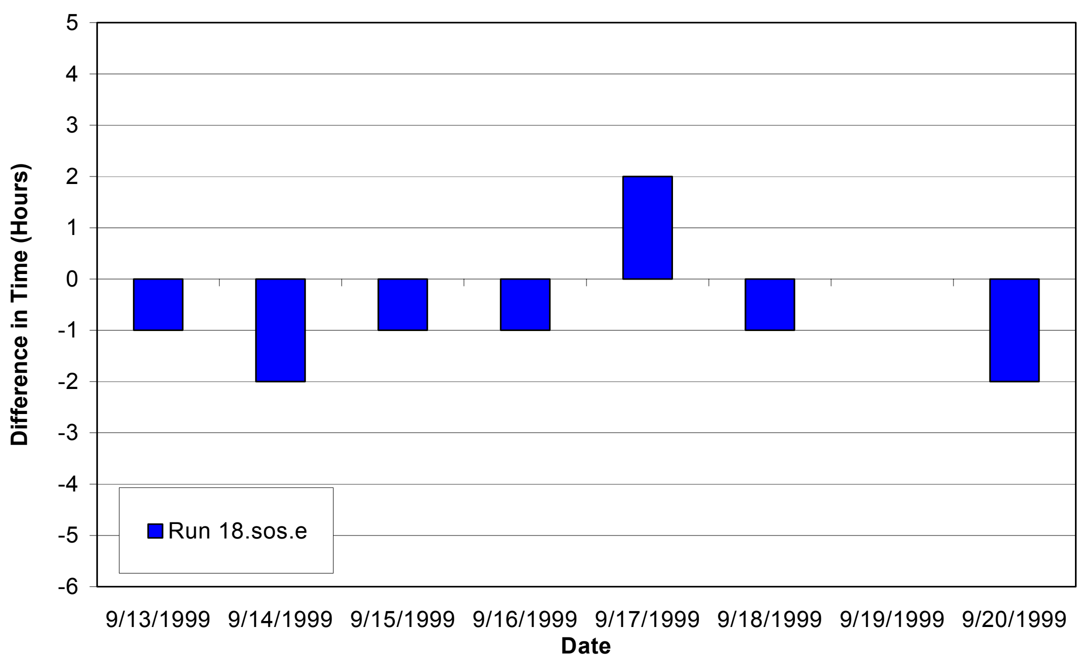


Figure E-19. 1-hour Fractional Bias at CAMS 23, September 13 – 20, 1999.

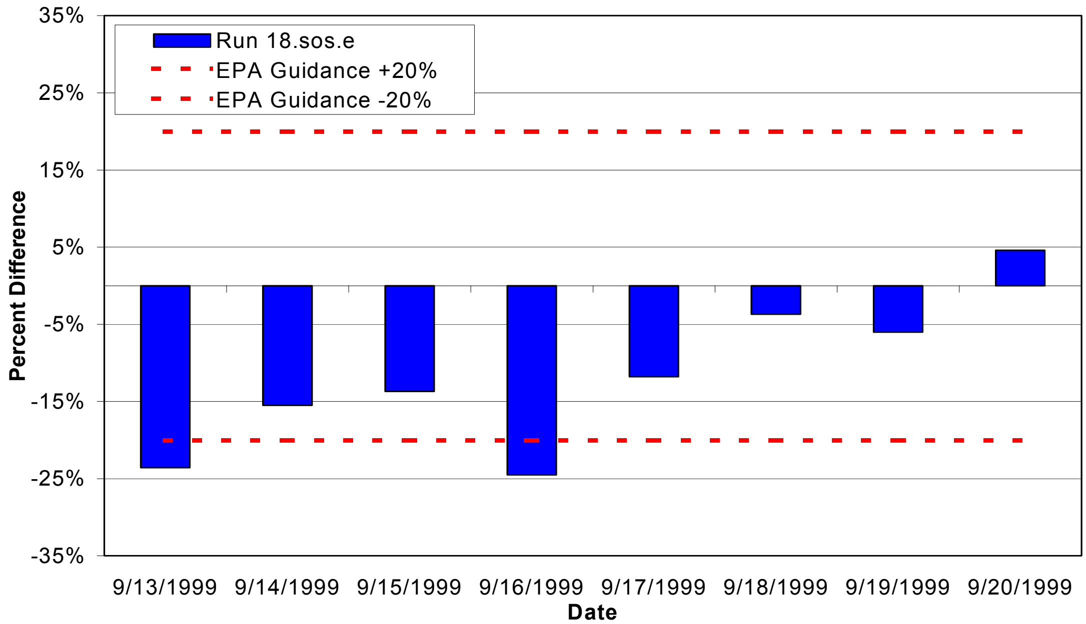


Figure E-20. 1-hour Fractional Bias at CAMS 58, September 13 – 20, 1999.

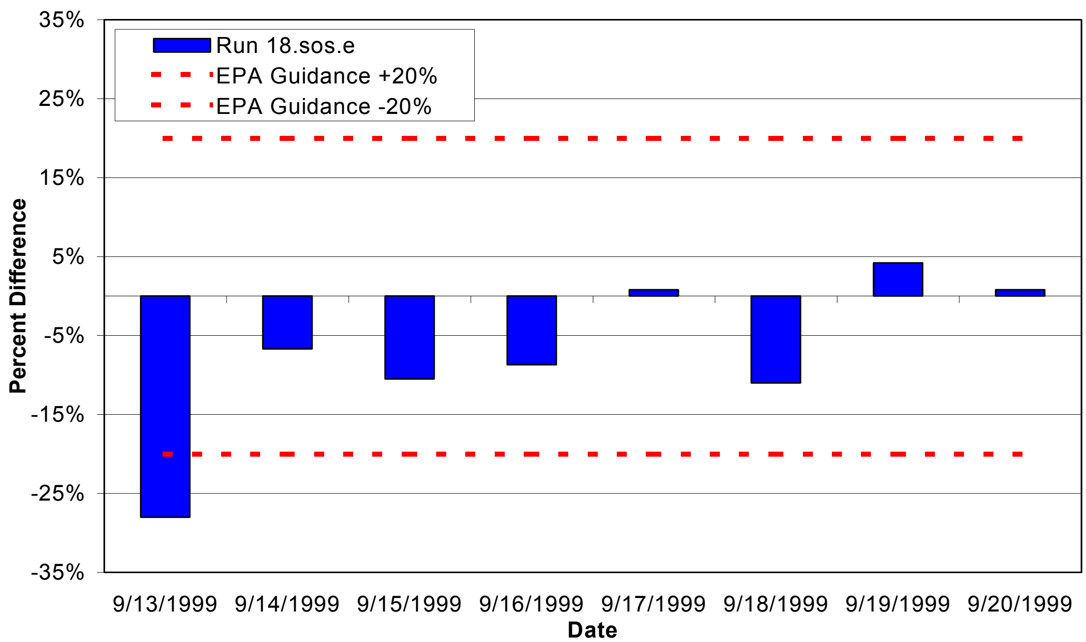
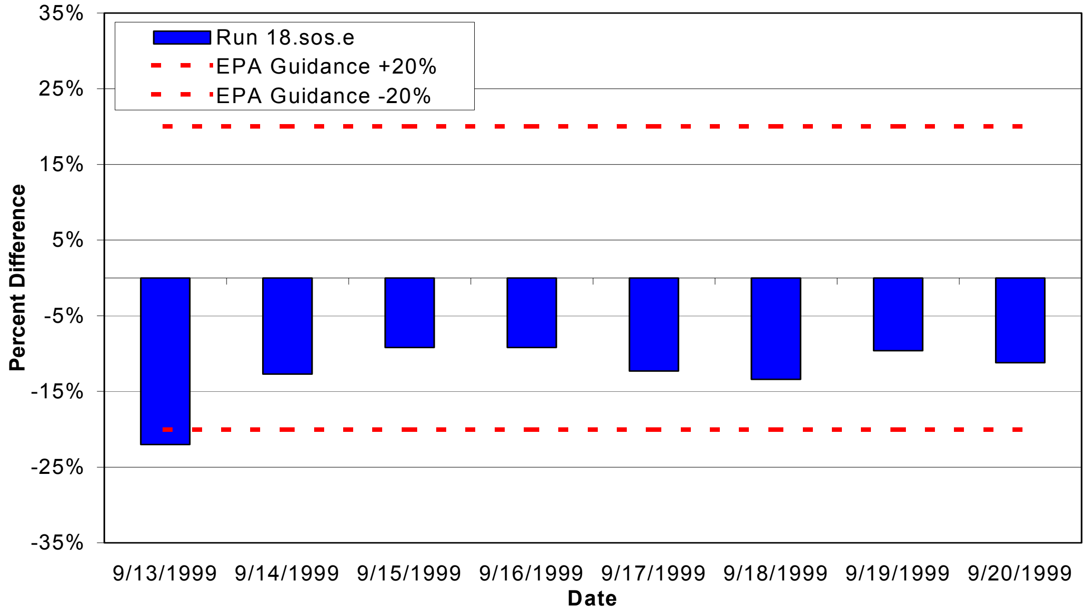


Figure E-21. 1-hour Fractional Bias at Central Texas Monitors 23 (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.



Time Series Plots

In addition to conducting 1-hour statistical measurements, staff produced time series plots of observed versus predicted 1-hour ozone concentrations. These plots provide an indication of the model's ability to replicate peak predictions, the presence of bias within the diurnal cycles, as well as biases in timing of the predicted daily maxima. Time series plots for the four San Antonio area monitors are provided in figures E-22 through E-25. These graphs indicate that diurnal trends were replicated quite well, although peak concentrations were slightly under-predicted at CAMS 23, 58, and 678 during several episode days. Peak concentrations at CAMS 59 were consistently under predicted, except for the final day of the episode, September 20th.

Figure E-22. Observed versus Predicted 1-hour Average Ozone Concentrations at CAMS 23, September 13 – 20, 1999.

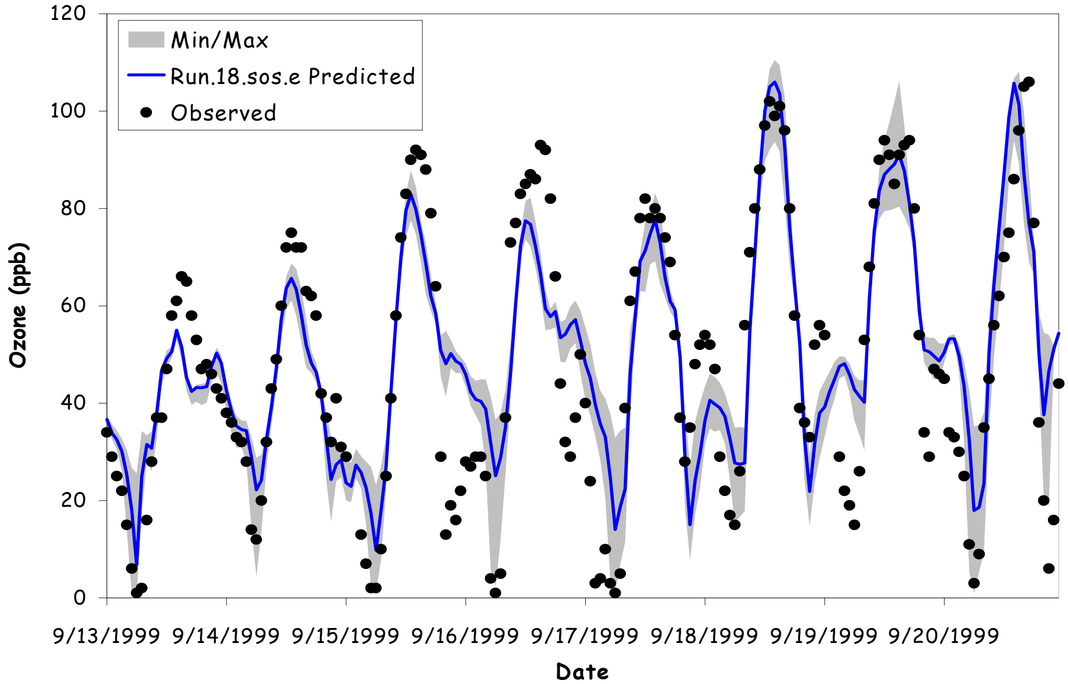


Figure E-23. Observed versus Predicted 1-hour Average Ozone Concentrations at CAMS 58, September 13 – 20, 1999.

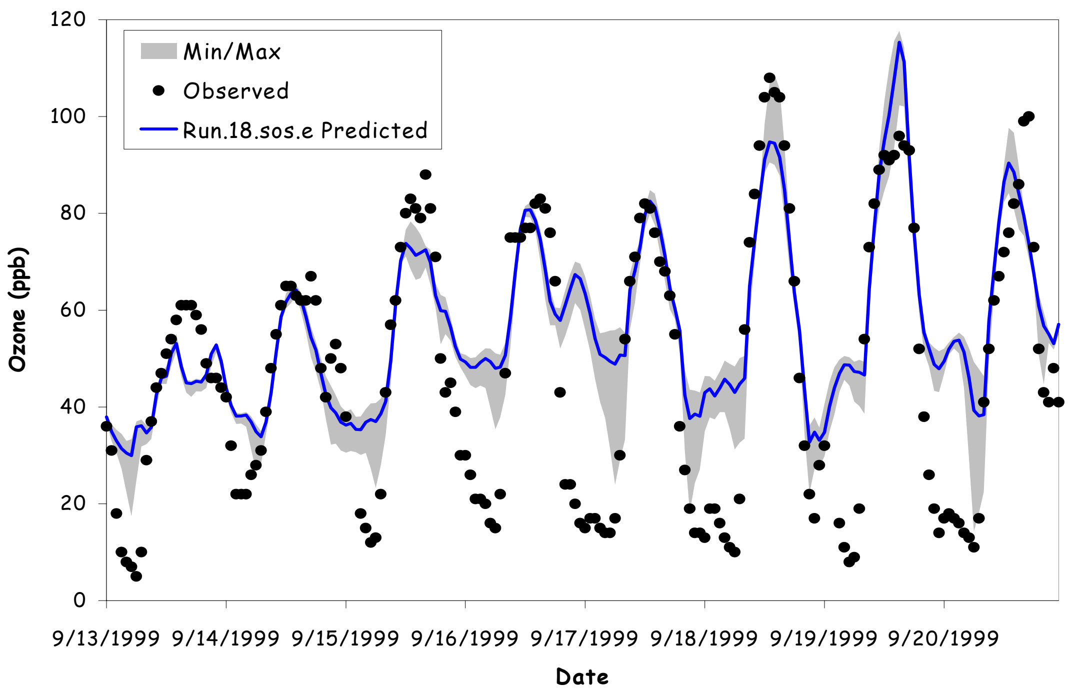


Figure E-24. Observed versus Predicted 1-hour Average Ozone Concentrations at CAMS 59, September 13 – 20, 1999.

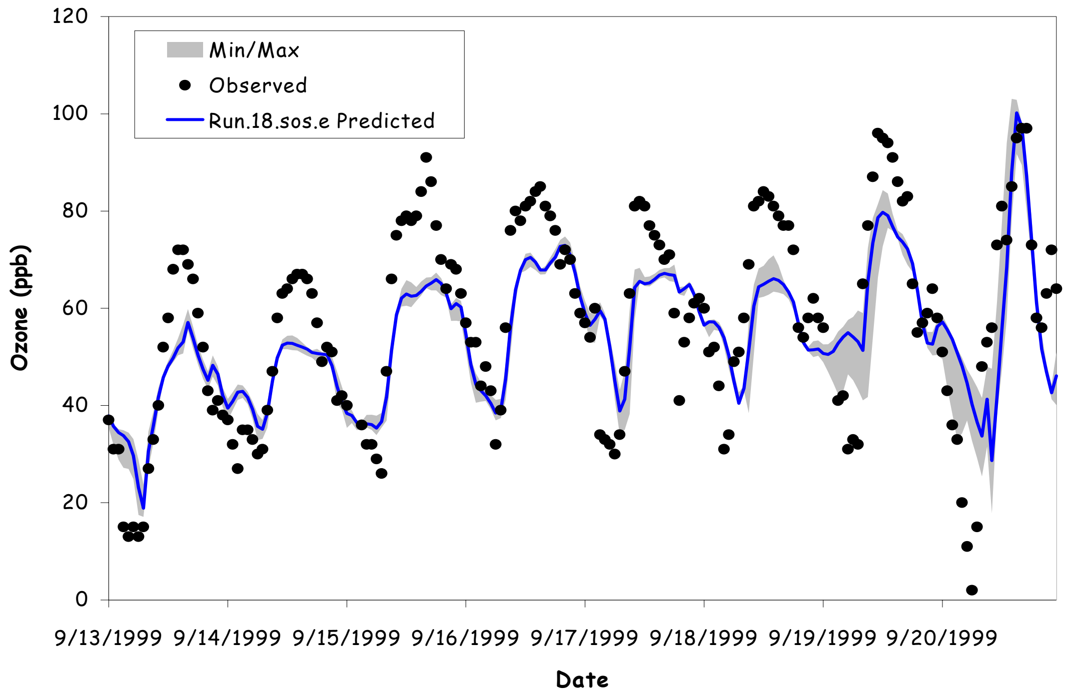
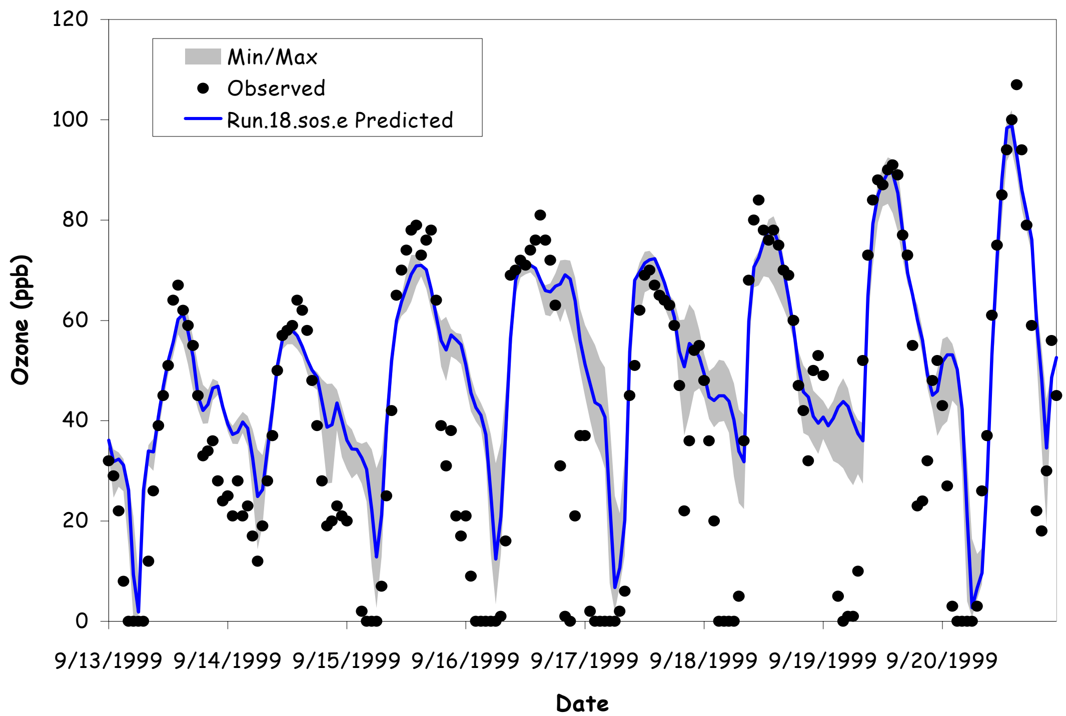


Figure E-25. Observed versus Predicted 1-hour Average Ozone Concentrations at CAMS 678, September 13 – 20, 1999.



Scatter Plots

Scatter plots of 1-hour observed (x) and predicted (y) data for the four SAER monitors are provided in figures E-26 through E-29. The observed/predicted data points for each monitor follows the 1:1 reference line fairly well and each plot exhibits moderate, positive correlation coefficients. Some outlier data pairs are evident in each chart, however.

Figure E-26. Scatter Plot of 1-hour Observed/Predicted Data Pairs at CAMS 23.

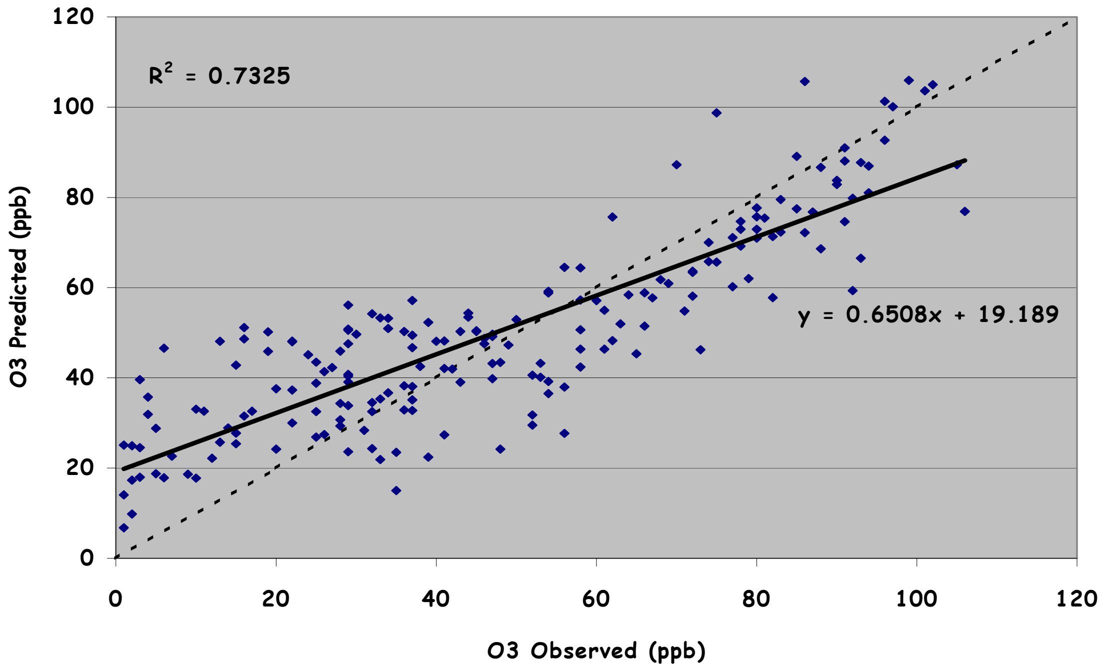


Figure E-27. Scatter Plot of 1-hour Observed/Predicted Data Pairs at CAMS 58.

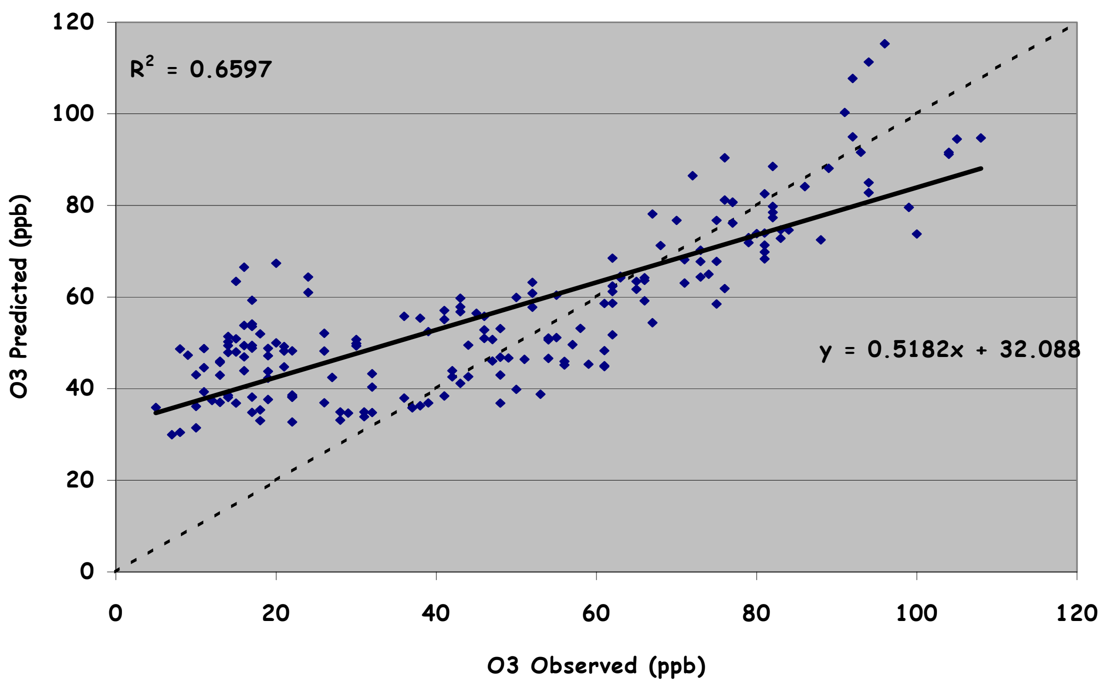


Figure E-28. Scatter Plot of 1-hour Observed/Predicted Data Pairs at CAMS 59.

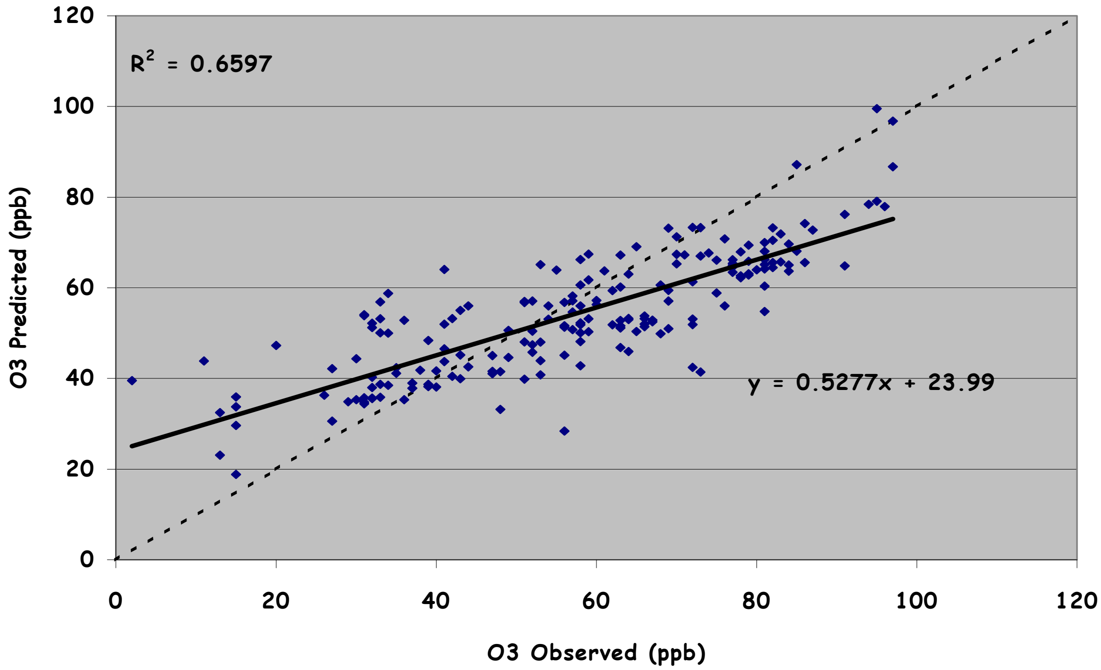
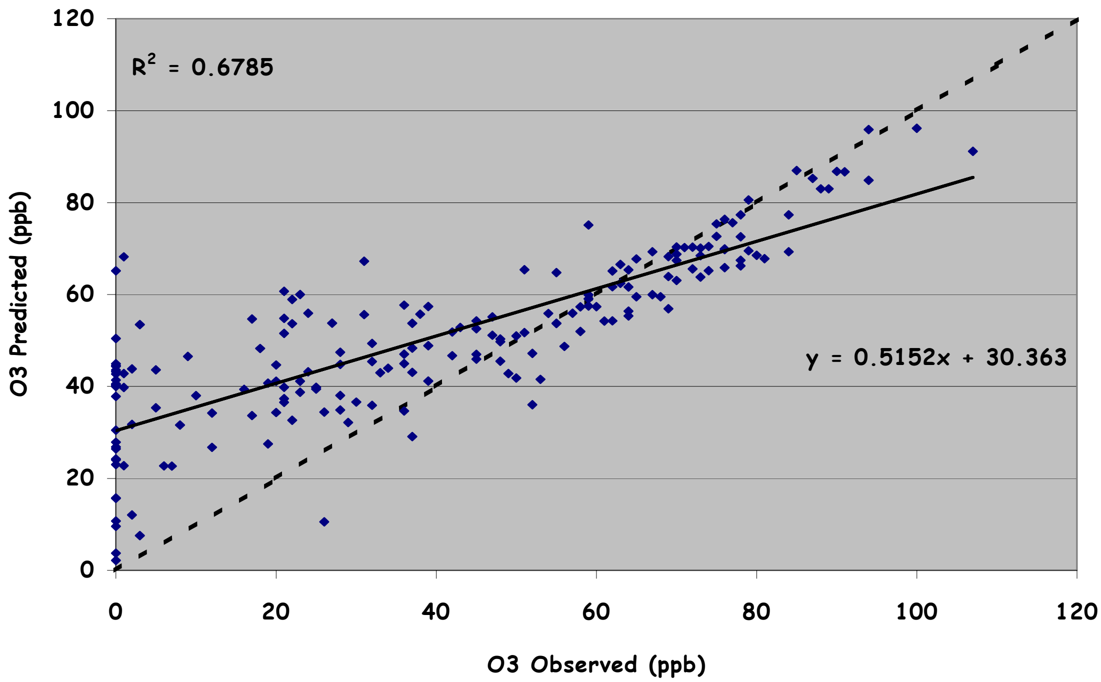


Figure E-29. Scatter Plot of 1-hour Observed/Predicted Data Pairs at CAMS 678.



Weekend/Weekday Comparisons
Weekend/weekday analyses may be useful for determining whether the model responds appropriately to changes in precursor emission rates. Typically, EIs for weekdays are very different than weekends. For example, vehicle miles traveled (VMT) are generally lower on weekends than weekdays. In areas such as San Antonio where mobile sources are the primary source of NOx emissions, this means the NOx EIs for Saturday and Sunday are the lowest of the week.

Figure E-30 provides a comparison between predicted/observed 1-hour average ozone concentrations at CAMS 23 and the daily NOx EI for Bexar County. As shown, observed and predicted concentrations track fairly closely throughout the episode. Both curves show a rise in ozone concentrations on Saturday as the result of lower NOx emissions (NOx reduction disbenefit). Higher ozone concentrations were predicted at CAMS 58 (figure E-31) on Saturday and Sunday, although actual 1-hour measurements fell on Sunday.

Figure E-32 aggregates the predicted peak concentrations (September 13 – 20, 1999) of the four San Antonio area monitors into a single chart and compares the data to the daily NOx EI for Bexar County. Unlike the predictions at CAMS 23 and 58, the peak predictions at CAMS 59 and 678 do not rise as sharply between Friday, September 17th and Saturday, September 18th. These results are consistent with expectations since CAMS 59 and 678 are upwind monitors.

Figure E-30. Comparison of Observed/predicted 1-hour Concentrations at CAMS 23 and Daily NOx EI for Bexar County, September 13 – 20, 1999.

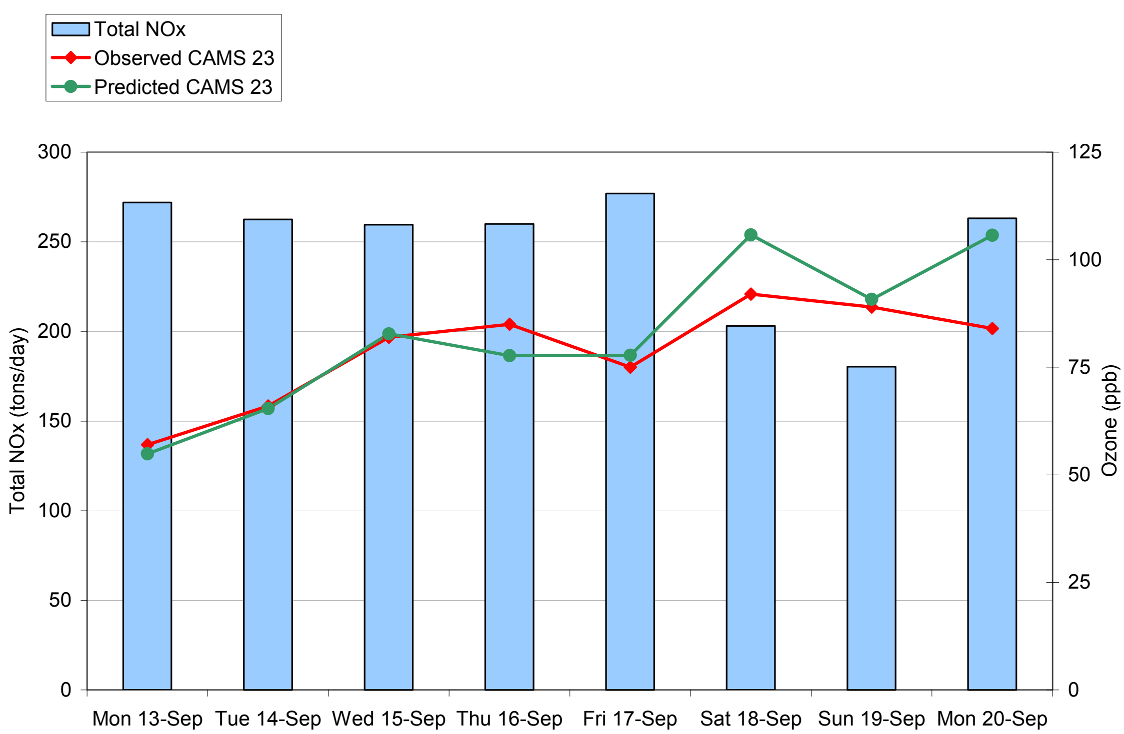


Figure E-31. Comparison of Observed/predicted 1-hour Concentrations at CAMS 58 and Daily NOx EI for Bexar County, September 13 – 20, 1999.

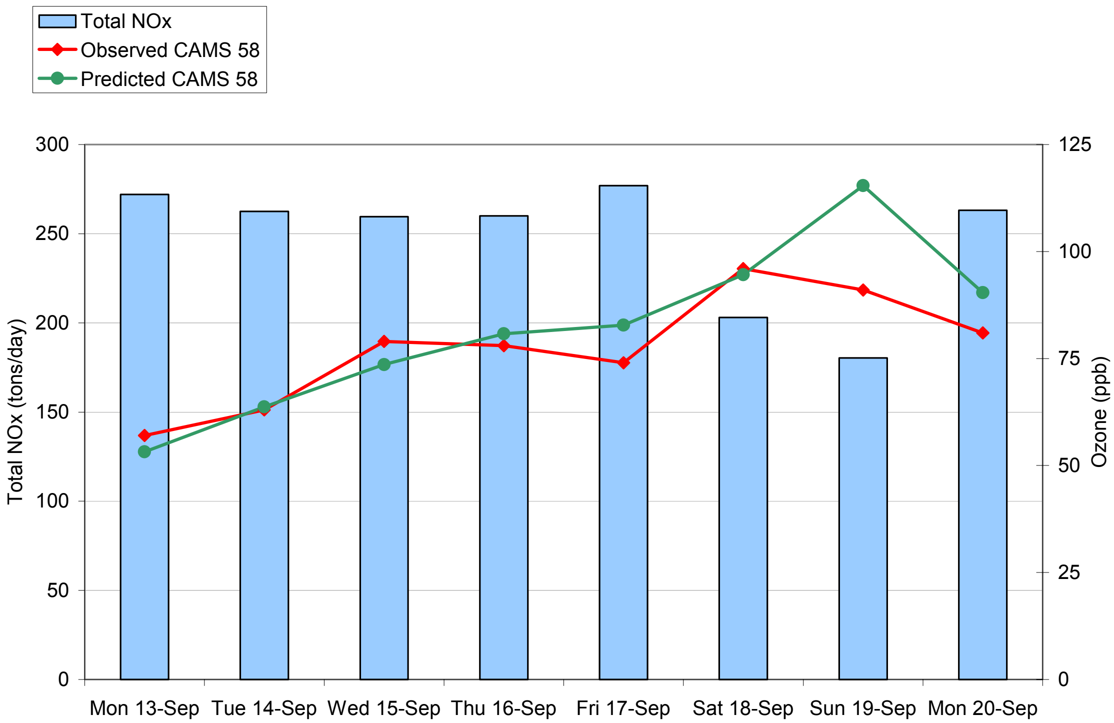
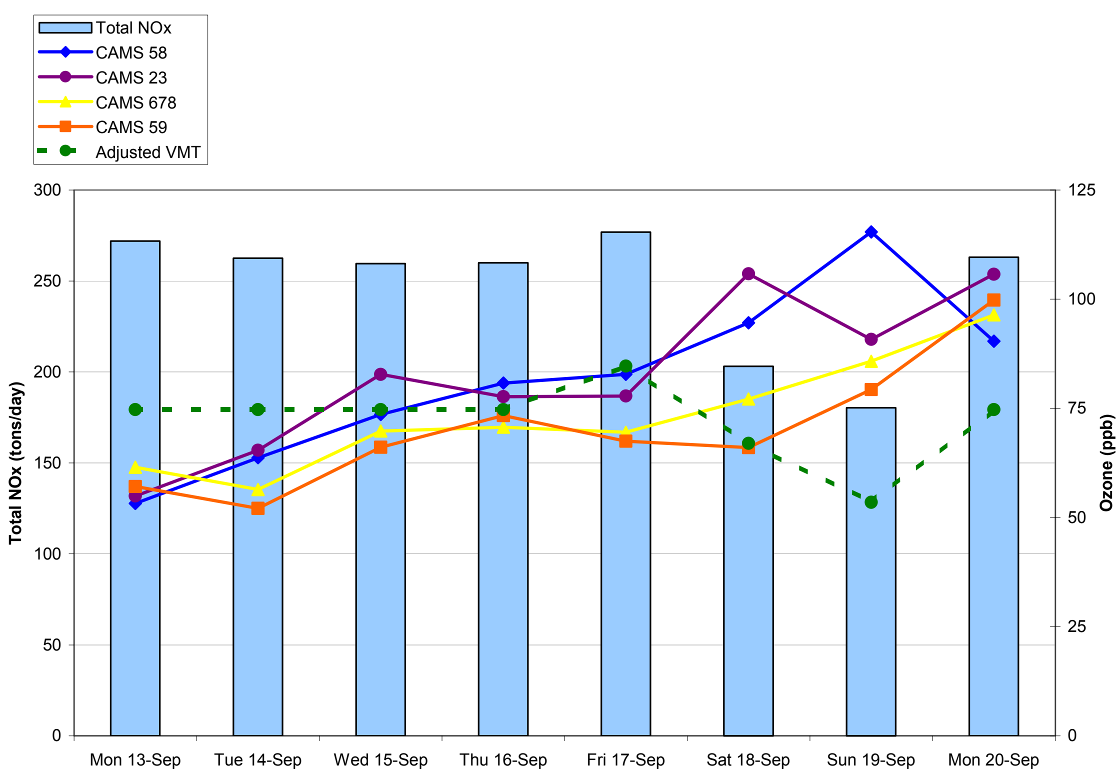


Figure E-32. Comparison of Observed/predicted 1-hour Concentrations at Four San Antonio CAMS and Daily NOx EI for Bexar County, September 13 – 20, 1999.



Model Performance: 8-Hour Average Ozone Concentrations
In their draft 8-hour guidance, the U.S. EPA recommends conducting a variety of tests to evaluate a photochemical model. In broad terms, these evaluations include performance tests and diagnostic analyses. Both types of evaluations were conducted on the September 1999 simulation with excellent results. The performance tests, used to determine how well the model predicted 8-hour concentrations are described in the following sections on ozone metrics, graphic analyses, and tile plots

Ozone Metrics
Metrics are used to evaluate how closely predicted ozone concentrations match observations, both in terms of spatial and temporal distributions. To evaluate the performance of the 1999 base case, staff conducted statistical tests from EPA's 1-hour and 8-hour guidance documents. To apply the 1-hour metrics to 8-hour data, staff utilized ENVIRON's "camxpost" program, described in the 1-hour statistics section. The program provided unpaired peak accuracy (UPA), average paired peak accuracy (APPA), peak timing bias (PTB), normalized bias (NB), fractional bias, normalized error (NE), and fractional error (FE) for peak 8-hour data. Results of these 8-hour tests are provided in tables E-18 through E-34. Whenever daily modeled predictions were less than 60 ppb, statistical tests were not performed. These days are indicated by "N/A" in the appropriate columns.

Yellow-highlighted values in these tables represent statistics that fall outside EPA's performance criteria on primary episode days (September 15 – 20, 1999. Although it is not necessary to conduct these tests on model initialization days (September 13-14, 1999), statistics for the initialization period are included for comparison purposes. Model initialization statistics that fall outside performance thresholds are listed in bold type. Columns where data are missing represent days in which predicted measurements were less than 60 ppb.

EPA recommends grouping monitored data in terms of location, i.e., downwind, upwind, and city center, as a means of developing useful comparisons. Averaged metrics tests were conducted for groups of monitors when possible.[2] The Central Texas monitoring network is relatively sparse; consequently, the Austin and San Antonio areas, in conjunction with the TCEQ and the U.S. EPA Region 6, recommended evaluating performance based on averaged data from all Central Texas stations. As a result, metrics tests were applied to averaged results at all eight Central Texas monitors, as well as groups of monitors. Monitor numbers, locations, and monitor groups are as follows:

[2] Austin has two monitors, both of which are downwind. San Antonio has two downwind, two upwind, and no city center monitors. As a consequence, there are no average statistics for city center for Austin, San Antonio or Central Texas.

CAMS #	Monitor Name/ Group Name	Location	AIRS #
3	Murchison	Travis County	48-453-0014
4	Corpus Christi West	Nueces County	48-355-0025
21	Corpus Christi Tuloso	Nueces County	48-355-0026
23	San Antonio Northwest	Bexar County	48-029-0032
38	Audubon	Travis County	48-453-0020
58	Camp Bullis	Bexar County	48-029-0052
59	Calaveras Lake	Bexar County	48-029-0059
62	San Marcos	Caldwell County	48-055-0062
87	Victoria	Victoria County	48-469-0003
601	Fayette	Fayette County	48-149-0001
678	CPS Pecan Valley	Bexar County	48-029-0055
3, 38	Austin Downwind Monitors	Travis County	
23, 58	San Antonio Downwind Monitors	Bexar County	
59, 678	San Antonio Upwind Monitors	Bexar County	
23, 58, 59, 678	San Antonio Monitors	Bexar County	
3, 23, 38,58	Central Texas Downwind Mntrs	Bexar, Travis	
59, 62, 601, 678	Central Texas Upwind Mntrs	Bexar, Caldwell, Fayette	
3, 23, 38, 58, 59, 62, 601, 678	Central Texas Monitors	Bexar, Caldwell, Fayette, Travis	

Applying the same performance criteria recommended for 1-hour statistics to peak 8-hour observed/predicted data comparisons, the results are excellent. Although a few individual monitors exhibit results that fall outside EPA thresholds (such as the negative bias exhibited by the coastal monitors), outcomes for monitor groups generally fell within acceptable ranges. The sole exception was unpaired peak accuracy on September 18th when testing paired data for San Antonio upwind monitors and Central Texas upwind monitors.

Table E-18. 8-hour Statistics for CAMS 3, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	N/A	18.9%	13.0%	-0.9%	-1.3%	-0.9%	8.8%
APPA	N/A	N/A	1.2%	-6.7%	-14.3%	-8.7%	-4.4%	-19.0%
PTB	N/A	N/A	0	1	0	1	0	0
NB	N/A	N/A	3.1%	-4.8%	-12.9%	-10.9%	-3.3%	-18.2%
FB	N/A	N/A	3.0%	-5.0%	-13.8%	-12.1%	-3.5%	-20.2%
NE	N/A	N/A	3.1%	5.6%	12.9%	11.4%	5.6%	18.2%
FE	N/A	N/A	3.0%	5.8%	13.8%	12.6%	5.7%	20.2%

Table E-19. 8-hour Statistics for CAMS 38, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	9.9%	3.3%	-8.4%	-11.5%	-13.0%	-11.1%	26.7%
APPA	N/A	-7.1%	-9.5%	-12.7%	-13.7%	-19.0%	-18.3%	-16.3%
PTB	N/A	0	1	0	0	1	1	-1
NB	N/A	-6.8%	-6.0%	-10.4%	-15.4%	-17.0%	-10.7%	-17.3%
FB	N/A	-7.1%	-6.2%	-11.0%	-16.9%	-19.0%	-11.7%	-19.1%
NE	N/A	6.8%	6.0%	10.4%	15.4%	17.0%	10.9%	17.3%
FE	N/A	7.1%	6.3%	11.0%	16.9%	19.0%	11.9%	19.1%

Table E-20. 8-hour Statistics for Austin Downwind Monitors (CAMS 3 & 38), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	9.9%	3.3%	-8.4%	-11.5%	-13.0%	-11.1%	8.8%
APPA	N/A	-7.1%	-4.1%	-9.7%	-14.0%	-13.8%	-11.4%	-17.6%
PTB	N/A	0	1	1	0	1	1	-1
NB	N/A	-6.8%	-3.7%	-8.7%	-14.4%	-14.8%	-7.8%	-17.7%
FB	N/A	-7.1%	-3.9%	-9.2%	-15.7%	-16.5%	-8.5%	-19.6%
NE	N/A	6.8%	5.3%	9.0%	14.4%	15.0%	8.9%	17.7%
FE	N/A	7.1%	5.5%	9.4%	15.7%	16.7%	9.5%	19.6%

Table E-21. 8-hour Statistics for CAMS 23, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	3.5%	1.1%	-1.2%	13.6%	6.3%	13.4%	10.5%
APPA	N/A	-14.7%	-12.9%	-20.8%	0.0%	-0.3%	-5.0%	4.0%
PTB	N/A	-1	0	0	1	0	0	0
NB	N/A	-14.0%	-9.3%	-16.6%	-7.9%	-1.4%	-2.0%	8.0%
FB	N/A	-15.1%	-9.9%	-18.3%	-8.3%	-1.5%	-2.0%	7.6%
NE	N/A	14.0%	9.3%	16.6%	7.9%	3.6%	3.6%	8.0%
FE	N/A	15.1%	9.9%	18.3%	8.3%	3.6%	3.7%	7.6%

Table E-22. 8-hour Statistics for CAMS 58, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	9.0%	5.0%	8.1%	16.0%	2.0%	11.8%	14.2%
APPA	N/A	-6.3%	-11.1%	-5.9%	0.7%	-11.1%	7.9%	-0.8%
PTB	N/A	0	0	0	1	0	0	-1
NB	N/A	-5.3%	-6.7%	-3.1%	3.1%	-7.8%	11.2%	1.2%
FB	N/A	-5.5%	-7.0%	-3.2%	3.0%	-8.2%	10.4%	1.2%
NE	N/A	5.3%	7.1%	4.3%	3.2%	7.8%	11.2%	2.9%
FE	N/A	5.5%	7.4%	4.4%	3.2%	8.2%	10.4%	2.8%

Table E-23. 8-hour Statistics for CAMS 59, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-9.6%	1.9%	2.0%	-6.1%	1.1%	21.6%	14.2%	10.8%
APPA	-20.2%	-18.6%	-21.2%	-13.3%	-12.9%	-19.7%	-15.5%	-7.2%
PTB	0	1	2	4	1	1	0	1
NB	**-19.6%**	**-17.2%**	-16.8%	-9.6%	-6.8%	-17.0%	-9.6%	-11.2%
FB	-21.8%	-18.9%	-18.5%	-10.3%	-7.5%	-18.7%	-10.2%	-12.1%
NE	19.6%	17.2%	16.8%	10.2%	10.1%	17.0%	9.6%	11.2%
FE	21.8%	18.9%	18.5%	11.0%	10.7%	18.7%	10.2%	12.1%

Table E-24. 8-hour Statistics for CAMS 678, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	N/A	12.6%	9.8%	31.1%	29.5%	20.1%	7.6%
APPA	N/A	N/A	-10.1%	-7.5%	2.6%	-5.9%	-4.8%	-1.7%
PTB	N/A	N/A	1	0	-1	0	0	1
NB	N/A	N/A	-6.3%	-5.2%	3.7%	-4.0%	-0.4%	0.1%
FB	N/A	N/A	-6.5%	-5.3%	3.6%	-4.1%	-0.6%	-0.2%
NE	N/A	N/A	6.3%	5.2%	3.7%	4.1%	5.6%	6.7%
FE	N/A	N/A	6.5%	5.3%	3.6%	4.2%	5.6%	6.6%

Table E-25. 8-hour Statistics for San Antonio Downwind Monitors (CAMS 23 & 58), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	3.5%	1.1%	-1.2%	13.6%	2.0%	11.8%	10.5%
APPA	N/A	10.5%	-12.0%	-13.3%	-4.1%	-5.7%	1.5%	1.6%
PTB	N/A	-1	0	0	1	0	0	-1
NB	N/A	-10.1%	-7.7%	-10.3%	-2.4%	-4.4%	4.6%	4.2%
FB	N/A	-10.8%	-8.1%	-11.2%	-2.6%	-4.7%	4.2%	4.2%
NE	N/A	10.1%	8.0%	10.9%	5.6%	5.6%	7.4%	5.1%
FE	N/A	10.8%	8.4%	11.8%	5.7%	5.8%	7.1%	4.9%

Table E-26. 8-hour Statistics for San Antonio Upwind Monitors (CAMS 59 & 678), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-9.6%	1.9%	2.0%	-6.1%	1.1%	21.6%	14.2%	7.6%
APPA	-20.2%	-18.6%	-15.6%	-10.4%	-5.2%	-12.8%	-10.2%	-4.4%
PTB	0	1	2	2	0	1	0	1
NB	**-19.6%**	**-17.2%**	-13.5%	-8.5%	-3.8%	-12.4%	-6.1%	-6.2%
FB	-21.8%	-18.9%	-14.7%	-9.1%	-4.3%	-13.6%	-6.5%	-6.8%
NE	19.6%	17.2%	13.5%	9.0%	8.3%	12.5%	8.1%	9.2%
FE	21.8%	18.9%	14.7%	9.6%	8.7%	13.6%	8.4%	9.7%

Table E-27. 8-hour Statistics for all San Antonio Monitors (CAMS 23, 58, 59 & 678) September 13 – 20, 1999.San Antonio Monitors

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-9.6%	3.5%	1.1%	-1.2%	1.1%	2.0%	11.8%	7.6%
APPA	-20.2%	-13.2%	-13.8%	-11.9%	-4.7%	-9.3%	-4.3%	-1.4%
PTB	0	0	1	1	1	0	0	0
NB	**-19.6%**	-12.7%	-10.9%	-9.3%	-3.1%	-8.5%	-0.9%	-1.3%
FB	-21.8%	-13.7%	-11.8%	-10.0%	-3.5%	-9.2%	-1.3%	-1.8%
NE	19.6%	12.7%	11.0%	9.8%	6.9%	9.1%	7.7%	7.3%
FE	21.8%	13.7%	11.9%	10.5%	7.2%	9.8%	7.8%	7.4%

Table E-28. 8-hour Statistics for CAMS 601, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	N/A	6.3%	28.9%	-0.6%	3.2%	11.5%	17.0%
APPA	N/A	N/A	-2.2%	1.2%	-14.4%	-5.8%	-3.0%	1.7%
PTB	N/A	N/A	-1	1	-1	1	-3	0
NB	N/A	N/A	-3.5%	1.2%	-15.4%	-12.2%	-11.1%	-3.2%
FB	N/A	N/A	-3.6%	1.2%	-16.9%	-13.2%	-12.2%	-3.3%
NE	N/A	N/A	3.5%	1.4%	15.4%	12.2%	11.5%	3.6%
FE	N/A	N/A	3.6%	1.4%	16.9%	13.2%	12.7%	3.7%

Table E-29. 8-hour Statistics for CAMS 62, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	N/A	15.1%	13.1%	2.9%	13.0%	10.1%	24.5%
APPA	N/A	N/A	-6.1%	6.8%	-13.3%	-11.0%	-6.7%	3.3%
PTB	N/A	N/A	-1	1	6	1	0	0
NB	N/A	N/A	-2.1%	6.9%	-7.7%	-8.3%	-2.8%	4.2%
FB	N/A	N/A	-2.1%	6.6%	-8.6%	-8.7%	-3.0%	4.1%
NE	N/A	N/A	3.3%	6.9%	11.8%	8.3%	5.8%	4.2%
FE	N/A	N/A	3.3%	6.6%	12.5%	8.7%	5.9%	4.1%

Table E-30. 8-hour Statistics for Central Texas Downwind Monitors (CAMS 3, 23, 38, 58) September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	N/A	3.5%	1.1%	-8.4%	-11.5%	-13.0%	-11.1%	8.8%
APPA	N/A	-9.4%	-8.1%	-11.5%	-9.1%	-9.8%	-5.0%	-8.0%
PTB	N/A	0	0	0	1	1	0	-1
NB	N/A	-9.3%	-5.4%	-9.5%	-10.1%	-10.9%	-3.0%	-8.5%
FB	N/A	-10.8%	-8.1%	-11.2%	-2.6%	-4.7%	4.2%	4.0%
NE	N/A	9.3%	6.4%	9.9%	11.2%	11.4%	8.3%	12.4%
FE	N/A	9.9%	6.7%	10.5%	12.1%	12.6%	8.6%	13.4%

Table E-31. 8-hour Statistics for Central Texas Upwind Monitors (CAMS 59, 62, 601, 678) September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-9.6%	1.9%	2.0%	-6.1%	-0.6%	21.6%	14.2%	7.6%
APPA	-20.2%	-18.6%	-9.6%	-3.0%	-8.4%	-10.1%	-7.1%	3.2%
PTB	0	1	0	2	1	1	-1	1
NB	**-19.6%**	**-17.2%**	-8.5%	-3.9%	-8.5%	-11.0%	-6.9%	-3.1%
FB	-21.8%	-18.9%	-9.2%	-4.3%	-9.4%	-11.9%	-7.6%	-3.4%
NE	19.6%	17.2%	8.8%	6.9%	12.2%	11.0%	8.9%	6.5%
FE	21.8%	18.9%	9.5%	7.3%	13.0%	11.9%	9.3%	6.7%

Table E-32. 8-hour Statistics for Central Texas (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-9.6%	3.5%	1.1%	-8.4%	-11.5%	-13.0%	-11.1%	8.8%
APPA	-20.2%	-11.7%	-9.0%	-7.3%	-9.3%	-10.2%	-6.2%	-4.5%
PTB	0	0	0	1	1	1	0	0
NB	**-19.6%**	-11.6%	-7.1%	-6.7%	-9.5%	-11.0%	-4.9%	5.9%
FB	21.8%	-12.5%	-7.6%	-7.3%	-10.4%	-12.1%	-5.5%	-6.7%
NE	19.6%	11.6%	7.7%	8.4%	11.5%	11.3%	8.5%	9.5%
FE	21.8%	12.5%	8.2%	8.9%	12.3%	12.4%	9.0%	10.1%

Table E-33. 8-hour Statistics for Corpus Christi Monitors (CAMS 4 & 21), September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	4.1%	-5.5%	0.8%	-5.3%	-3.6%	-1.4%	1.6%	-1.2%
APPA	-25.7%	-21.7%	-22.2%	-22.6%	-19.6%	-10.1%	-6.1%	-22.6%
PTB	0	1	1	0	-2	-1	2	2
NB	**-27.2%**	**-22.4%**	-19.9%	-23.4%	-18.8%	-14.1%	-7.6%	-24.2%
FB	-31.7%	-25.5%	-22.1%	-26.5%	-20.9%	-15.7%	-8.4%	-27.8%
NE	27.2%	22.4%	19.9%	23.4%	18.8%	14.3%	9.2%	24.2%
FE	31.7%	25.5%	22.1%	26.5%	20.9%	15.9%	9.9%	27.8%

Table E-34. 8-hour Statistics for CAMS 87, September 13 – 20, 1999.

Statistic	13-Sep	14-Sep	15-Sep	16-Sep	17-Sep	18-Sep	19-Sep	20-Sep
UPA	-4.5%	9.8%	13.2%	10.0%	8.2%	0.6%	0.4%	-15.9%
APPA	-31.2%	-12.9%	-6.4%	-3.1%	-5.3%	-15.2%	-4.3%	-18.9%
PTB	0	-1	-1	0	1	-1	0	1
NB	**-28.8%**	-12.8%	-6.0%	-1.3%	-7.9%	-18.8%	-16.4%	-15.6%
	-33.6%	-13.7%	-6.3%	-1.4%	-8.3%	-20.8%	-19.4%	-17.6%
NE	28.8%	12.8%	6.3%	2.7%	7.9%	18.8%	16.4%	17.2%
FE	33.6%	13.7%	6.6%	2.8%	8.3%	20.8%	19.4%	19.1%

A variety of analyses are specifically recommended by the EPA in their draft guidance on 8-hour attainment demonstrations (EPA 1999). These include:

- Bias between spatially paired means of observations and predictions of 8-hour daily maximum ozone concentrations, with predicted values based on grid cells 'near' a monitor.
- Correlation coefficient and scatter plot for average observed and predicted 8-hour daily maximum ozone concentrations.
- Temporal correlation coefficient of observed and nearby predicted 8-hour daily maximum ozone concentrations, which are spatially averaged. If the monitoring network is sufficiently large, concentrations should be grouped into upwind, downwind, and center city locations.
- Quantile-quantile plots
- Fractional bias

The EPA-recommended performance goal for each test is:

Test	Goal
Bias between predicted/observed mean 8-hour (and 1-hour) daily maxima near each monitor	20% most monitors (8-hr comparisons only)
Fractional bias between predicted/ Observed mean 8-hour (and 1-hour) daily maxima near each monitor	20% most monitors (8-hr comparisons only)
Correlation coefficients, all data, temporally paired means, spatially paired means	Moderate to large positive correlation
Bias (8-hour daily maxima and 1-hour observed/predicted), all monitors	5 – 15%
Gross error (8-hour daily maxima and 1-hour observed/predicted), all monitors	30 – 35%

Staff conducted metric, scatter plot, and quantile-quantile (Q-Q) plot analyses using a FORTRAN program developed by ENVIRON International, Inc. Due to some uncertainty as to the most appropriate means of calculating these evaluations, ENVIRON's statistical program performs the calculations using three different methodologies:

1) The predicted daily maximum ozone concentration within grid cells near a monitor;[3]
2) The predicted daily maximum ozone concentration within grid cells near a monitor that is closest in magnitude to the observed daily maximum at the monitor; and
3) A bilinear interpolation of predicted daily maximum ozone concentration around the monitor location.

Normalized bias, fractional bias, normalized error, and fractional error calculations for all monitors and monitoring groups in the 4-km subdomain are provided in tables E-35 through E-51. Each table presents the statistical results for all three methodologies.

To compare 8-hour normalized bias statistics more readily, line graphs were created of downwind, upwind, and coastal monitors for each methodology (figures E-33 through E-35). Episode day is designated by a number (1 = 9/13/99, 2 = 9/14/99, 3 = 9/15/99, 4 = 9/16/99, 5 = 9/17/99, 6 = 9/18/99, 7 = 9/19/99, and 8 = 9/20/99) in each graph. The model initialization period (days 1 and 2) are separated by a dashed black line and performance goals are designated by dashed red lines.

Method 1 for calculating normalized bias yields very good results. Discounting the model initialization period, the only days when EPA performance goals were not met using

[3] In accordance with EPA guidance, grid cells 'near' a monitor were defined as a 7x7 array of cells (U.S. EPA, 1999).

method 1were September 15th (CAMS 59 – San Antonio upwind monitor), and September 19th (CAMS 23 and 58 – San Antonio downwind monitors).

Model performance based on the statistical metrics was best when calculated using method 2. The ±20% performance goal for normalized bias was only exceeded once using this method: September 15th at CAMS 59.

Method 3 yielded the most incidences where performance goals were not met. With the exception of CAMS 23, the normalized bias statistics for each downwind monitor failed performance goals during at least one primary episode day. These include CAMS 38 (Austin) on September 16th, 18th, and 20th, CAMS 3 (Austin) on September 20th, and CAMS 58 (San Antonio) on September 19th. Both Austin monitors (CAMS 3 & 38) are downwind monitors and both exhibited a negative bias during the modeling episode. Normalized bias calculated using method 3 yielded better results for the upwind monitors. The only days when performance goals were not met were September 15th and 18th, both at CAMS 59 (San Antonio). In addition, all three coastal monitors failed the normalized bias goal with method 3 on at least one episode day: CAMS 4 (Corpus Christi) on September 15th and 16th, CAMS 21 (Corpus Christi) on September 15th, and CAMS 87 (Victoria) on September 20th.

Line graphs of fractional bias statistics were also developed for each methodology. These graphs are presented in figures E-36 through E-38. Results of the fractional bias calculations are very similar to those for normalized bias, although the incidence of results that failed to meet performance goals increased somewhat with fractional bias. For the daily peak predicted/observed statistics (September 15 – 20, 1999) using Method 1, for example, the performance goal for normalized bias was met on 95% of the days and the performance goal for fractional bias was met on 94% of the days. Using method 2, the ±20% goal for normalized and fractional bias was met on 98% and 97% of the days, respectively. The poorest performance was associated with evaluating the model using method 3. Even using this strictest methodology, however, the performance goals for normalized and fractional bias were passed on 85% of the primary episode days.

Table E-35. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 3, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	53.00	56.21	6.06	5.88	6.06	5.88
9/14/1999	56.00	70.02	**25.04**	**22.25**	25.04	22.25
9/15/1999	78.00	89.62	14.90	13.86	14.90	13.86
9/16/1999	73.00	79.73	9.22	8.81	9.22	8.81
9/17/1999	98.00	102.26	4.35	4.25	4.35	4.25
9/18/1999	97.00	98.17	1.21	1.20	1.21	1.20
9/19/1999	101.00	104.52	3.49	3.43	3.49	3.43
9/20/1999	102.00	103.21	1.19	1.18	1.19	1.18

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	53.00	52.95	-0.09	-0.09	0.09	0.09
9/14/1999	56.00	55.79	-0.38	-0.38	0.38	0.38
9/15/1999	78.00	78.05	0.06	0.06	0.06	0.06
9/16/1999	73.00	73.03	0.04	0.04	0.04	0.04
9/17/1999	98.00	97.40	-0.61	-0.61	0.61	0.61
9/18/1999	97.00	97.00	0.00	0.00	0.00	0.00
9/19/1999	101.00	100.89	-0.11	-0.11	0.11	0.11
9/20/1999	102.00	103.21	1.19	1.18	1.19	1.18

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	53.00	51.49	-2.85	-2.89	2.85	2.89
9/14/1999	56.00	58.35	4.20	4.11	4.20	4.11
9/15/1999	78.00	79.62	2.08	2.06	2.08	2.06
9/16/1999	73.00	68.84	-5.70	-5.87	5.70	5.87
9/17/1999	98.00	88.69	-9.50	-9.97	9.50	9.97
9/18/1999	97.00	90.65	-6.55	-6.77	6.55	6.77
9/19/1999	101.00	98.81	-2.17	-2.19	2.17	2.19
9/20/1999	102.00	72.45	-28.97	-33.88	28.97	33.88

Table E-36. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 38, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	57.00	56.73	-0.47	-0.47	0.47	0.47
9/14/1999	66.00	64.87	-1.71	-1.73	1.71	1.73
9/15/1999	83.00	86.06	3.69	3.62	3.69	3.62
9/16/1999	100.00	82.48	-17.52	-19.20	17.52	19.20
9/17/1999	109.00	102.26	-6.18	-6.38	6.18	6.38
9/18/1999	120.00	98.17	-18.19	-20.01	18.19	20.01
9/19/1999	110.00	104.63	-4.88	-5.00	4.88	5.00
9/20/1999	83.00	72.89	-12.18	-12.97	12.18	12.97

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	57.00	56.73	-0.47	-0.47	0.47	0.47
9/14/1999	66.00	64.87	-1.71	-1.73	1.71	1.73
9/15/1999	83.00	83.16	0.19	0.19	0.19	0.19
9/16/1999	100.00	82.48	-17.52	-19.20	17.52	19.20
9/17/1999	109.00	102.26	-6.18	-6.38	6.18	6.38
9/18/1999	120.00	98.17	-18.19	-20.01	18.19	20.01
9/19/1999	110.00	104.63	-4.88	-5.00	4.88	5.00
9/20/1999	83.00	72.89	-12.18	-12.97	12.18	12.97

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	57.00	55.57	-2.51	-2.54	2.51	2.54
9/14/1999	66.00	59.72	-9.52	-9.99	9.52	9.99
9/15/1999	83.00	77.19	-7.00	-7.25	7.00	7.25
9/16/1999	100.00	79.95	-20.05	-22.28	20.05	22.28
9/17/1999	109.00	95.70	-12.20	-12.99	12.20	12.99
9/18/1999	120.00	87.69	-26.93	-31.11	26.93	31.11
9/19/1999	110.00	99.42	-9.62	-10.10	9.62	10.10
9/20/1999	83.00	64.17	-22.69	-25.59	22.69	25.59

Table E-37. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for Austin monitors – CAMS 3 & 38 (both are downwind monitors), September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	55.00	56.47	2.79	2.70	3.27	3.18
9/14/1999	61.00	67.45	11.66	10.26	13.37	11.99
9/15/1999	80.50	87.84	9.29	8.74	9.29	8.74
9/16/1999	86.50	81.11	-4.15	-5.19	13.37	14.01
9/17/1999	103.50	102.26	-0.92	-1.06	5.27	5.32
9/18/1999	108.50	98.17	-8.49	-9.41	9.70	10.61
9/19/1999	105.50	104.58	-0.70	-0.79	4.18	4.21
9/20/1999	92.50	88.05	-5.50	-5.90	6.68	7.07

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	55.00	54.84	-0.28	-0.28	0.28	0.28
9/14/1999	61.00	60.33	-1.04	-1.05	1.04	1.05
9/15/1999	80.50	80.61	0.13	0.13	0.13	0.13
9/16/1999	86.50	77.76	-8.74	-9.58	8.78	9.62
9/17/1999	103.50	99.83	-3.40	-3.50	3.40	3.50
9/18/1999	108.50	97.59	-9.10	-10.01	9.10	10.01
9/19/1999	105.50	102.76	-2.50	-2.56	2.50	2.56
9/20/1999	92.50	88.05	-5.50	-5.90	6.68	7.07

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	55.00	53.53	-2.68	-2.72	2.68	2.72
9/14/1999	61.00	59.04	-2.66	-2.94	6.86	7.05
9/15/1999	80.50	78.41	-2.46	-2.60	4.54	4.65
9/16/1999	86.50	74.40	-12.87	-14.07	12.87	14.07
9/17/1999	103.50	92.20	-10.85	-11.48	10.85	11.48
9/18/1999	108.50	89.17	-16.74	-18.94	16.74	18.94
9/19/1999	105.50	99.12	-5.89	-6.15	5.89	6.15
9/20/1999	92.50	68.31	-25.83	-29.73	25.83	29.73

Table E-38. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 23, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	66.00	56.73	-14.05	-15.11	14.05	15.11
9/14/1999	75.00	73.79	-1.61	-1.63	1.61	1.63
9/15/1999	92.00	97.21	5.66	5.51	5.66	5.51
9/16/1999	93.00	88.59	-4.74	-4.86	4.74	4.86
9/17/1999	82.00	91.47	11.55	10.92	11.55	10.92
9/18/1999	102.00	110.88	8.71	8.34	8.71	8.34
9/19/1999	94.00	118.52	26.09	23.08	26.09	23.08
9/20/1999	106.00	112.50	6.13	5.95	6.13	5.95

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	66.00	56.73	-14.05	-15.11	14.05	15.11
9/14/1999	75.00	73.79	-1.61	-1.63	1.61	1.63
9/15/1999	92.00	92.01	0.01	0.01	0.01	0.01
9/16/1999	93.00	88.59	-4.74	-4.86	4.74	4.86
9/17/1999	82.00	82.29	0.35	0.35	0.35	0.35
9/18/1999	102.00	102.16	0.16	0.16	0.16	0.16
9/19/1999	94.00	94.69	0.73	0.73	0.73	0.73
9/20/1999	106.00	105.99	-0.01	-0.01	0.01	0.01

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	66.00	54.88	-16.85	-18.40	16.85	18.40
9/14/1999	75.00	65.41	-12.79	-13.66	12.79	13.66
9/15/1999	92.00	82.80	-10.00	-10.53	10.00	10.53
9/16/1999	93.00	77.74	-16.41	-17.88	16.41	17.88
9/17/1999	82.00	77.80	-5.12	-5.26	5.12	5.26
9/18/1999	102.00	105.79	3.72	3.65	3.72	3.65
9/19/1999	94.00	90.81	-3.39	-3.45	3.39	3.45
9/20/1999	106.00	105.71	-0.27	-0.27	0.27	0.27

Table E-39. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 58, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	61.00	57.07	-6.44	-6.66	6.44	6.66
9/14/1999	67.00	70.82	5.70	5.54	5.70	5.54
9/15/1999	88.00	87.19	-0.92	-0.92	0.92	0.92
9/16/1999	83.00	86.38	4.07	3.99	4.07	3.99
9/17/1999	82.00	91.67	11.79	11.14	11.79	11.14
9/18/1999	108.00	110.88	2.67	2.63	2.67	2.63
9/19/1999	96.00	118.52	23.46	21.00	23.46	21.00
9/20/1999	100.00	106.71	6.71	6.49	6.71	6.49

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	61.00	57.07	-6.44	-6.66	6.44	6.66
9/14/1999	67.00	67.01	0.01	0.01	0.01	0.01
9/15/1999	88.00	87.19	-0.92	-0.92	0.92	0.92
9/16/1999	83.00	83.06	0.07	0.07	0.07	0.07
9/17/1999	82.00	81.93	-0.09	-0.09	0.09	0.09
9/18/1999	108.00	108.53	0.49	0.49	0.49	0.49
9/19/1999	96.00	95.72	-0.29	-0.29	0.29	0.29
9/20/1999	100.00	99.51	-0.49	-0.49	0.49	0.49

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	61.00	53.22	-12.75	-13.62	12.75	13.62
9/14/1999	67.00	63.68	-4.96	-5.08	4.96	5.08
9/15/1999	88.00	73.64	-16.32	-17.77	16.32	17.77
9/16/1999	83.00	80.83	-2.61	-2.65	2.61	2.65
9/17/1999	82.00	82.77	0.94	0.93	0.94	0.93
9/18/1999	108.00	94.55	-12.45	-13.28	12.45	13.28
9/19/1999	96.00	115.42	20.23	18.37	20.23	18.37
9/20/1999	100.00	90.40	-9.60	-10.08	9.60	10.08

Table E-40. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 59, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	72.00	62.13	-13.71	-14.72	13.71	14.72
9/14/1999	67.00	56.70	-15.37	-16.65	15.37	16.65
9/15/1999	91.00	70.87	-22.12	-24.87	22.12	24.87
9/16/1999	85.00	76.10	-10.47	-11.05	10.47	11.05
9/17/1999	82.00	73.04	-10.93	-11.56	10.93	11.56
9/18/1999	84.00	77.42	-7.83	-8.15	7.83	8.15
9/19/1999	96.00	90.71	-5.51	-5.67	5.51	5.67
9/20/1999	97.00	103.84	7.05	6.81	7.05	6.81

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	72.00	62.13	-13.71	-14.72	13.71	14.72
9/14/1999	67.00	56.70	-15.37	-16.65	15.37	16.65
9/15/1999	91.00	70.87	-22.12	-24.87	22.12	24.87
9/16/1999	85.00	76.10	-10.47	-11.05	10.47	11.05
9/17/1999	82.00	73.04	-10.93	-11.56	10.93	11.56
9/18/1999	84.00	77.42	-7.83	-8.15	7.83	8.15
9/19/1999	96.00	90.71	-5.51	-5.67	5.51	5.67
9/20/1999	97.00	97.01	0.01	0.01	0.01	0.01

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	72.00	57.06	**-20.75**	**-23.15**	20.75	23.15
9/14/1999	67.00	52.09	**-22.25**	**-25.04**	22.25	25.04
9/15/1999	91.00	66.07	-27.40	-31.74	27.40	31.74
9/16/1999	85.00	73.35	-13.71	-14.71	13.71	14.71
9/17/1999	82.00	67.48	-17.71	-19.43	17.71	19.43
9/18/1999	84.00	65.96	-21.48	-24.06	21.48	24.06
9/19/1999	96.00	79.28	-17.42	-19.08	17.42	19.08
9/20/1999	97.00	99.84	2.93	2.89	2.93	2.89

Table E-41. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 678, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	67.00	63.05	-5.90	-6.07	5.90	6.07
9/14/1999	64.00	60.99	-4.70	-4.82	4.70	4.82
9/15/1999	79.00	78.00	-1.27	-1.27	1.27	1.27
9/16/1999	81.00	76.83	-5.15	-5.28	5.15	5.28
9/17/1999	70.00	75.71	8.16	7.84	8.16	7.84
9/18/1999	84.00	88.35	5.18	5.05	5.18	5.05
9/19/1999	91.00	96.07	5.57	5.42	5.57	5.42
9/20/1999	107.00	108.27	1.19	1.18	1.19	1.18

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	67.00	63.05	-5.90	-6.07	5.90	6.07
9/14/1999	64.00	60.99	-4.70	-4.82	4.70	4.82
9/15/1999	79.00	78.00	-1.27	-1.27	1.27	1.27
9/16/1999	81.00	76.83	-5.15	-5.28	5.15	5.28
9/17/1999	70.00	70.14	0.20	0.20	0.20	0.20
9/18/1999	84.00	85.89	2.25	2.22	2.25	2.22
9/19/1999	91.00	91.06	0.07	0.07	0.07	0.07
9/20/1999	107.00	107.02	0.02	0.02	0.02	0.02

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	67.00	61.47	-8.25	-8.61	8.25	8.61
9/14/1999	64.00	56.38	-11.91	-12.66	11.91	12.66
9/15/1999	79.00	69.83	-11.61	-12.32	11.61	12.32
9/16/1999	81.00	70.67	-12.75	-13.62	12.75	13.62
9/17/1999	70.00	69.50	-0.71	-0.72	0.71	0.72
9/18/1999	84.00	77.14	-8.17	-8.51	8.17	8.51
9/19/1999	91.00	85.83	-5.68	-5.85	5.68	5.85
9/20/1999	107.00	96.44	-9.87	-10.38	9.87	10.38

Table E-42. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for San Antonio downwind monitors (CAMS 23 & 58), September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	63.50	56.90	-10.24	-10.88	10.24	10.88
9/14/1999	71.00	72.31	2.04	1.96	3.66	3.58
9/15/1999	90.00	92.20	2.37	2.29	3.29	3.22
9/16/1999	88.00	87.49	-0.33	-0.43	4.41	4.42
9/17/1999	82.00	91.57	11.67	11.03	11.67	11.03
9/18/1999	105.00	110.88	5.69	5.49	5.69	5.49
9/19/1999	95.00	118.52	24.77	22.04	24.77	22.04
9/20/1999	103.00	109.61	6.42	6.22	6.42	6.22

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	63.50	56.90	-10.24	-10.88	10.24	10.88
9/14/1999	71.00	70.40	-0.80	-0.81	0.81	0.82
9/15/1999	90.00	89.60	-0.45	-0.46	0.47	0.47
9/16/1999	88.00	85.83	-2.33	-2.39	2.41	2.46
9/17/1999	82.00	82.11	0.13	0.13	0.22	0.22
9/18/1999	105.00	105.35	0.32	0.32	0.32	0.32
9/19/1999	95.00	95.21	0.22	0.22	0.51	0.51
9/20/1999	103.00	102.75	-0.25	-0.25	0.25	0.25

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	63.50	54.05	-14.80	-16.01	14.80	16.01
9/14/1999	71.00	64.55	-8.87	-9.37	8.87	9.37
9/15/1999	90.00	78.22	-13.16	-14.15	13.16	14.15
9/16/1999	88.00	79.29	-9.51	-10.26	9.51	10.26
9/17/1999	82.00	80.29	-2.09	-2.16	3.03	3.10
9/18/1999	105.00	100.17	-4.37	-4.82	8.08	8.46
9/19/1999	95.00	103.12	8.42	7.46	11.81	10.91
9/20/1999	103.00	98.06	-4.94	-5.18	4.94	5.18

Table E-43. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for San Antonio upwind monitors (CAMS 59 & 678), September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	69.50	62.59	-9.80	-10.40	9.80	10.40
9/14/1999	65.50	58.85	-10.04	-10.73	10.04	10.73
9/15/1999	85.00	74.44	-11.69	-13.07	11.69	13.07
9/16/1999	83.00	76.47	-7.81	-8.17	7.81	8.17
9/17/1999	76.00	74.38	-1.38	-1.86	9.54	9.70
9/18/1999	84.00	82.89	-1.33	-1.55	6.51	6.60
9/19/1999	93.50	93.39	0.03	-0.12	5.54	5.54
9/20/1999	102.00	106.06	4.12	4.00	4.12	4.00

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	69.50	62.59	-9.80	-10.40	9.80	10.40
9/14/1999	65.50	58.85	-10.04	-10.73	10.04	10.73
9/15/1999	85.00	74.44	-11.69	-13.07	11.69	13.07
9/16/1999	83.00	76.47	-7.81	-8.17	7.81	8.17
9/17/1999	76.00	71.59	-5.36	-5.68	5.56	5.88
9/18/1999	84.00	81.66	-2.79	-2.96	5.04	5.19
9/19/1999	93.50	90.89	-2.72	-2.80	2.79	2.87
9/20/1999	102.00	102.02	0.01	0.01	0.01	0.01

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	69.50	59.27	-14.50	-15.88	14.50	15.88
9/14/1999	65.50	54.24	**-17.08**	-18.85	17.08	18.85
9/15/1999	85.00	67.95	-19.50	-22.03	19.50	22.03
9/16/1999	83.00	72.01	-13.23	-14.17	13.23	14.17
9/17/1999	76.00	68.49	-9.21	-10.07	9.21	10.07
9/18/1999	84.00	71.55	-14.82	-16.29	14.82	16.29
9/19/1999	93.50	82.56	-11.55	-12.46	11.55	12.46
9/20/1999	102.00	98.14	-3.47	-3.75	6.40	6.63

Table E-44. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for San Antonio monitors (CAMS 23, 58, 59, 678), September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	66.50	59.75	-10.02	-10.64	10.02	10.64
9/14/1999	68.25	65.58	-4.00	-4.39	6.85	7.16
9/15/1999	87.50	83.32	-4.66	-5.39	7.49	8.14
9/16/1999	85.50	81.98	-4.07	-4.30	6.11	6.30
9/17/1999	79.00	82.97	5.14	4.58	10.61	10.36
9/18/1999	94.50	96.88	2.18	1.97	6.10	6.04
9/19/1999	94.25	105.96	12.40	10.96	15.16	13.79
9/20/1999	102.50	107.83	5.27	5.11	5.27	5.11

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	66.50	59.75	-10.02	-10.64	10.02	10.64
9/14/1999	68.25	64.62	-5.42	-5.77	5.43	5.78
9/15/1999	87.50	82.02	-6.07	-6.76	6.08	6.77
9/16/1999	85.50	81.15	-5.07	-5.28	5.11	5.32
9/17/1999	79.00	76.85	-2.61	-2.77	2.89	3.05
9/18/1999	94.50	93.50	-1.23	-1.32	2.68	2.76
9/19/1999	94.25	93.05	-1.25	-1.29	1.65	1.69
9/20/1999	102.50	102.38	-0.12	-0.12	0.13	0.13

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	66.50	56.66	-14.65	-15.95	14.65	15.95
9/14/1999	68.25	59.39	-12.98	-14.11	12.98	14.11
9/15/1999	87.50	73.09	-16.33	-18.09	16.33	18.09
9/16/1999	85.50	75.65	-11.37	-12.22	11.37	12.22
9/17/1999	79.00	74.39	-5.65	-6.12	6.12	6.58
9/18/1999	94.50	85.86	-9.60	-10.55	11.45	12.38
9/19/1999	94.25	92.84	-1.57	-2.50	11.68	11.69
9/20/1999	102.50	98.10	-4.20	-4.46	5.67	5.91

Table E-45. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 62, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	57.00	60.41	5.98	5.81	5.98	5.81
9/14/1999	N/A	N/A	N/A	N/A	N/A	N/A
9/15/1999	78.00	81.86	4.95	4.83	4.95	4.83
9/16/1999	70.00	76.98	9.97	9.50	9.97	9.50
9/17/1999	89.00	91.89	3.25	3.20	3.25	3.20
9/18/1999	83.00	76.84	-7.42	-7.71	7.42	7.71
9/19/1999	86.00	89.41	3.97	3.89	3.97	3.89
9/20/1999	78.00	82.58	5.87	5.70	5.87	5.70

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	57.00	56.97	-0.05	-0.05	0.05	0.05
9/14/1999	N/A	N/A	N/A	N/A	N/A	N/A
9/15/1999	78.00	78.06	0.08	0.08	0.08	0.08
9/16/1999	70.00	70.07	0.10	0.10	0.10	0.10
9/17/1999	89.00	88.86	-0.16	-0.16	0.16	0.16
9/18/1999	83.00	76.84	-7.42	-7.71	7.42	7.71
9/19/1999	86.00	86.12	0.14	0.14	0.14	0.14
9/20/1999	78.00	78.12	0.15	0.15	0.15	0.15

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	57.00	55.72	-2.25	-2.27	2.25	2.27
9/14/1999	N/A	N/A	N/A	N/A	N/A	N/A
9/15/1999	78.00	70.27	-9.91	-10.43	9.91	10.43
9/16/1999	70.00	73.52	5.03	4.91	5.03	4.91
9/17/1999	89.00	75.97	-14.64	-15.80	14.64	15.80
9/18/1999	83.00	72.92	-12.14	-12.93	12.14	12.93
9/19/1999	86.00	83.16	-3.30	-3.36	3.30	3.36
9/20/1999	78.00	78.12	0.15	0.15	0.15	0.15

Table E-46. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for CAMS 601, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	64.07	55.73	-13.02	-13.92	13.02	13.92
9/14/1999	56.23	58.65	4.30	4.21	4.30	4.21
9/15/1999	72.90	74.12	1.67	1.66	1.67	1.66
9/16/1999	70.94	76.39	7.68	7.40	7.68	7.40
9/17/1999	103.29	94.71	-8.31	-8.67	8.31	8.67
9/18/1999	87.12	88.14	1.17	1.16	1.17	1.16
9/19/1999	85.65	87.36	2.00	1.98	2.00	1.98
9/20/1999	87.12	97.28	11.66	11.02	11.66	11.02

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	64.07	55.73	-13.02	-13.92	13.02	13.92
9/14/1999	56.23	56.42	0.34	0.34	0.34	0.34
9/15/1999	72.90	72.26	-0.88	-0.88	0.88	0.88
9/16/1999	70.94	71.30	0.51	0.51	0.51	0.51
9/17/1999	103.29	94.71	-8.31	-8.67	8.31	8.67
9/18/1999	87.12	86.16	-1.10	-1.11	1.10	1.11
9/19/1999	85.65	86.12	0.55	0.55	0.55	0.55
9/20/1999	87.12	87.05	-0.08	-0.08	0.08	0.08

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	64.07	52.79	-17.61	-19.31	17.61	19.31
9/14/1999	56.23	54.16	-3.68	-3.75	3.68	3.75
9/15/1999	72.90	67.46	-7.46	-7.75	7.46	7.75
9/16/1999	70.94	72.28	1.89	1.87	1.89	1.87
9/17/1999	103.29	88.34	-14.47	-15.60	14.47	15.60
9/18/1999	87.12	78.53	-9.86	-10.37	9.86	10.37
9/19/1999	85.65	80.53	-5.98	-6.16	5.98	6.16
9/20/1999	87.12	90.63	4.03	3.95	4.03	3.95

Table E-47. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for Central Texas Downwind Monitors (CAMS 3, 23, 38, 58), September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	59.25	56.69	-3.73	-4.09	6.75	7.03
9/14/1999	66.00	69.88	6.85	6.11	8.52	7.79
9/15/1999	85.25	90.02	5.83	5.52	6.29	5.98
9/16/1999	87.25	84.30	-2.24	-2.81	8.89	9.22
9/17/1999	92.75	96.92	5.38	4.98	8.47	8.17
9/18/1999	106.75	104.53	-1.40	-1.96	7.69	8.05
9/19/1999	100.25	111.55	12.04	10.62	14.48	13.13
9/20/1999	97.75	98.83	0.46	0.16	6.55	6.65

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	59.25	55.87	-5.26	-5.58	5.26	5.58
9/14/1999	66.00	65.37	-0.92	-0.93	0.93	0.94
9/15/1999	85.25	85.10	-0.16	-0.16	0.30	0.30
9/16/1999	87.25	81.79	-5.54	-5.99	5.59	6.04
9/17/1999	92.75	90.97	-1.63	-1.68	1.81	1.86
9/18/1999	106.75	101.47	-4.39	-4.84	4.71	5.16
9/19/1999	100.25	98.98	-1.14	-1.17	1.50	1.53
9/20/1999	97.75	95.40	-2.87	-3.07	3.47	3.66

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	59.25	53.79	-8.74	-9.36	8.74	9.36
9/14/1999	66.00	61.79	-5.77	-6.16	7.86	8.21
9/15/1999	85.25	78.31	-7.81	-8.37	8.85	9.40
9/16/1999	87.25	76.84	-11.19	-12.17	11.19	12.17
9/17/1999	92.75	86.24	-6.47	-6.82	6.94	7.29
9/18/1999	106.75	94.67	-10.55	-11.88	12.41	13.70
9/19/1999	100.25	101.12	1.26	0.66	8.85	8.53
9/20/1999	97.75	83.18	-15.38	-17.46	15.38	17.46

Table E-48. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for Central Texas Upwind Monitors (CAMS 59, 62, 601, 678), September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	65.02	60.33	-6.66	-7.23	9.65	10.13
9/14/1999	62.41	58.78	-5.26	-5.75	8.13	8.56
9/15/1999	80.23	76.21	-4.19	-4.91	7.50	8.16
9/16/1999	76.74	76.58	0.51	0.14	8.32	8.31
9/17/1999	86.07	83.84	-1.96	-2.30	7.66	7.81
9/18/1999	84.53	82.69	-2.23	-2.41	5.40	5.52
9/19/1999	89.66	92.44	3.21	2.97	5.97	5.80
9/20/1999	92.28	97.99	6.44	6.18	6.44	6.18

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	65.02	59.47	-8.17	-8.69	8.17	8.69
9/14/1999	62.41	58.04	-6.58	-7.04	6.80	7.27
9/15/1999	80.23	74.80	-6.05	-6.74	6.09	6.78
9/16/1999	76.74	73.58	-3.75	-3.93	4.06	4.23
9/17/1999	86.07	81.69	-4.80	-5.05	4.90	5.15
9/18/1999	84.53	81.34	-3.81	-3.97	4.37	4.52
9/19/1999	89.66	88.50	-1.19	-1.23	1.57	1.60
9/20/1999	92.28	92.30	0.03	0.03	0.07	0.07

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	65.02	56.66	-12.37	-13.50	12.37	13.50
9/14/1999	62.41	54.43	-12.27	-13.43	12.27	13.43
9/15/1999	80.23	68.70	-13.72	-15.15	13.72	15.15
9/16/1999	76.74	72.67	-4.63	-5.10	8.08	8.48
9/17/1999	86.07	76.09	-10.79	-11.81	12.62	13.61
9/18/1999	84.53	73.87	-12.64	-13.67	12.64	13.67
9/19/1999	89.66	82.71	-7.53	-8.02	7.53	8.02
9/20/1999	92.28	91.82	-0.16	-0.27	3.72	3.77

Table E-49. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for Central Texas Monitors (CAMS 3, 23, 38, 58, 59, 62, 601, 678), September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	62.13	58.51	-5.19	-5.66	8.20	8.58
9/14/1999	64.46	65.12	1.66	1.03	8.35	8.12
9/15/1999	82.74	83.12	0.82	0.30	6.90	7.07
9/16/1999	81.99	80.44	-0.87	-1.34	8.60	8.76
9/17/1999	89.41	90.38	1.71	1.34	8.06	7.99
9/18/1999	95.64	93.61	-1.81	-2.19	6.55	6.78
9/19/1999	94.96	101.22	6.77	6.01	9.37	8.68
9/20/1999	95.02	98.41	3.45	3.17	6.50	6.41

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	62.13	57.67	-6.72	-7.14	6.72	7.14
9/14/1999	64.46	62.22	-3.35	-3.55	3.45	3.65
9/15/1999	82.74	79.95	-3.11	-3.45	3.19	3.54
9/16/1999	81.99	77.68	-4.64	-4.96	4.83	5.14
9/17/1999	89.41	86.33	-3.21	-3.36	3.35	3.50
9/18/1999	95.64	91.52	-3.96	-4.26	4.68	4.98
9/19/1999	94.96	93.74	-1.16	-1.20	1.54	1.57
9/20/1999	95.02	93.85	-1.42	-1.52	1.77	1.86

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	62.13	55.28	-10.48	-11.35	10.48	11.35
9/14/1999	64.46	58.54	-8.70	-9.44	9.90	10.61
9/15/1999	82.74	73.36	-10.95	-11.97	11.47	12.48
9/16/1999	81.99	74.65	-8.04	-8.78	9.77	10.47
9/17/1999	89.41	80.78	-9.18	-9.85	9.41	10.09
9/18/1999	95.64	84.15	-11.73	-12.92	12.66	13.84
9/19/1999	94.96	91.66	-3.42	-3.98	8.47	8.57
9/20/1999	95.02	87.22	-8.04	-9.15	9.81	10.90

Table E-50. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics (%) for Corpus Christi Monitors - CAMS 4 & 21, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	79.00	62.34	-19.60	**-22.29**	19.60	22.29
9/14/1999	83.00	69.91	-15.78	-17.13	15.78	17.13
9/15/1999	88.50	79.92	-9.58	-10.32	9.58	10.32
9/16/1999	84.00	79.98	-4.77	-4.91	4.77	4.91
9/17/1999	83.50	79.11	-5.27	-5.41	5.27	5.41
9/18/1999	92.00	99.94	8.64	8.28	8.64	8.28
9/19/1999	93.00	104.72	13.05	12.10	13.05	12.10
9/20/1999	84.00	86.88	3.58	3.49	3.58	3.49

Methodology 2:

Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	79.00	62.34	-19.60	**-22.29**	19.60	22.29
9/14/1999	83.00	69.91	-15.78	-17.13	15.78	17.13
9/15/1999	88.50	79.92	-9.58	-10.32	9.58	10.32
9/16/1999	84.00	79.98	-4.77	-4.91	4.77	4.91
9/17/1999	83.50	79.11	-5.27	-5.41	5.27	5.41
9/18/1999	92.00	92.10	0.11	0.11	0.11	0.11
9/19/1999	93.00	92.95	-0.06	-0.06	0.06	0.06
9/20/1999	84.00	84.13	0.15	0.15	0.15	0.15

Methodology 3:

Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	79.00	52.75	**-31.68**	**-38.39**	31.68	38.39
9/14/1999	83.00	62.39	**-24.76**	**-28.33**	24.76	28.33
9/15/1999	88.50	66.43	-24.94	-28.49	24.94	28.49
9/16/1999	84.00	68.27	-18.75	-20.72	18.75	20.72
9/17/1999	83.50	71.04	-14.92	-16.13	14.92	16.13
9/18/1999	92.00	91.27	-0.84	-0.95	4.59	4.63
9/19/1999	93.00	97.16	5.07	4.65	7.92	7.54
9/20/1999	84.00	72.78	-13.28	-14.24	13.28	14.24

Table E-51. Peak Predicted/observed 8-hour Average Concentrations and Ozone Metrics for CAMS 87, September 13 – 20, 1999.

Methodology 1:

Date	MAXOBS1HR	MAXPRD1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	86.00	51.09	**-40.59**	**-50.93**	**40.59**	**50.93**
9/14/1999	76.00	67.43	-11.28	-11.95	11.28	11.95
9/15/1999	92.00	88.02	-4.33	-4.42	4.33	4.42
9/16/1999	87.00	84.09	-3.34	-3.40	3.34	3.40
9/17/1999	93.00	90.29	-2.91	-2.96	2.91	2.96
9/18/1999	94.00	85.76	-8.77	-9.17	8.77	9.17
9/19/1999	92.00	91.37	-0.68	-0.69	0.68	0.69
9/20/1999	110.00	91.67	-16.66	-18.18	16.66	18.18

Methodology 2:

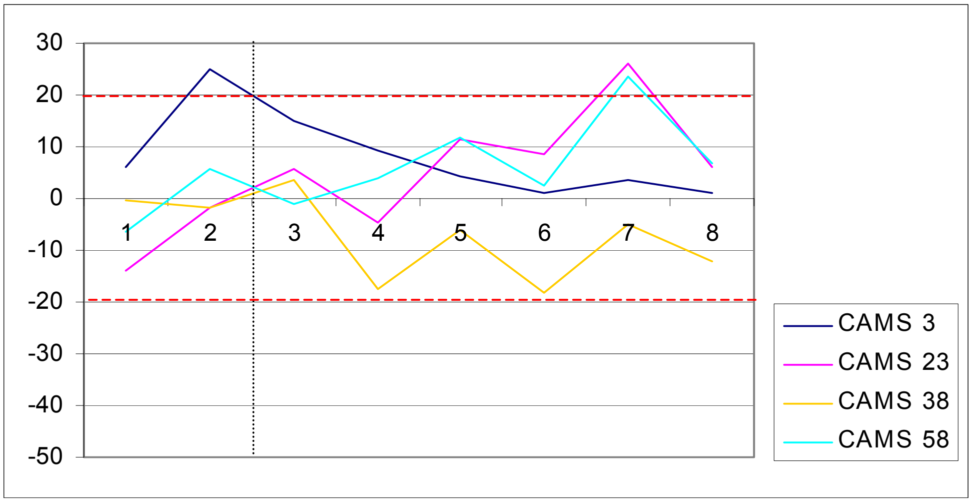
Date	MAXOBS1HR	NEAR1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	86.00	51.09	**-40.59**	**-50.93**	**40.59**	**50.93**
9/14/1999	76.00	67.43	-11.28	-11.95	11.28	11.95
9/15/1999	92.00	88.02	-4.33	-4.42	4.33	4.42
9/16/1999	87.00	84.09	-3.34	-3.40	3.34	3.40
9/17/1999	93.00	90.29	-2.91	-2.96	2.91	2.96
9/18/1999	94.00	85.76	-8.77	-9.17	8.77	9.17
9/19/1999	92.00	91.37	-0.68	-0.69	0.68	0.69
9/20/1999	110.00	91.67	-16.66	-18.18	16.66	18.18

Methodology 3:

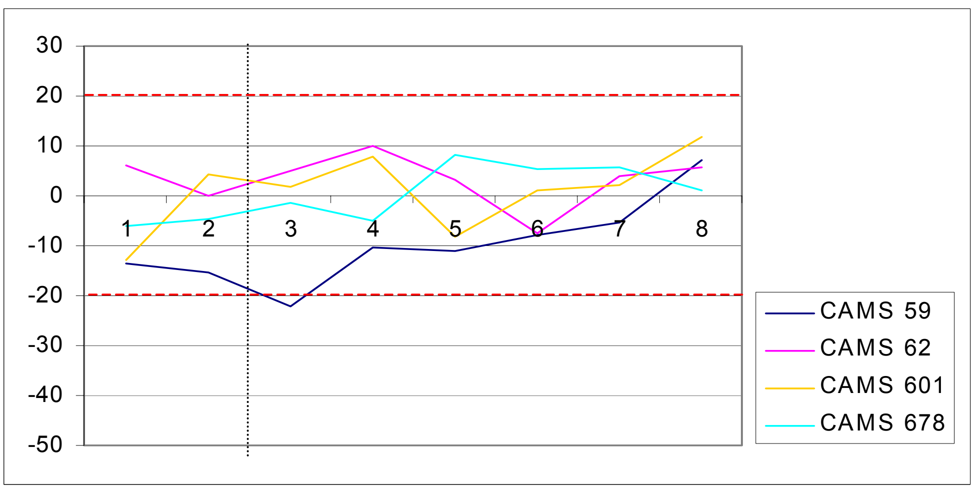
Date	MAXOBS1HR	CAMXPS1HR	Norm Bias	Fractional Bias	Norm Error	Fractional Error
9/13/1999	86.00	47.76	**-44.47**	**-57.18**	**44.47**	**57.18**
9/14/1999	76.00	61.97	-18.46	-20.34	18.46	20.34
9/15/1999	92.00	76.21	-17.16	-18.77	17.16	18.77
9/16/1999	87.00	81.47	-6.36	-6.56	6.36	6.56
9/17/1999	93.00	84.99	-8.61	-9.00	8.61	9.00
9/18/1999	94.00	76.46	-18.66	-20.58	18.66	20.58
9/19/1999	92.00	88.35	-3.97	-4.05	3.97	4.05
9/20/1999	110.00	87.70	-20.27	-22.56	20.27	22.56

Figure E-33. Normalized Bias for Downwind, Upwind, and Coastal Monitors Calculated using Method 1, September 13- 20, 1999.

Downwind Monitors:



Upwind Monitors:



Coastal Monitors:

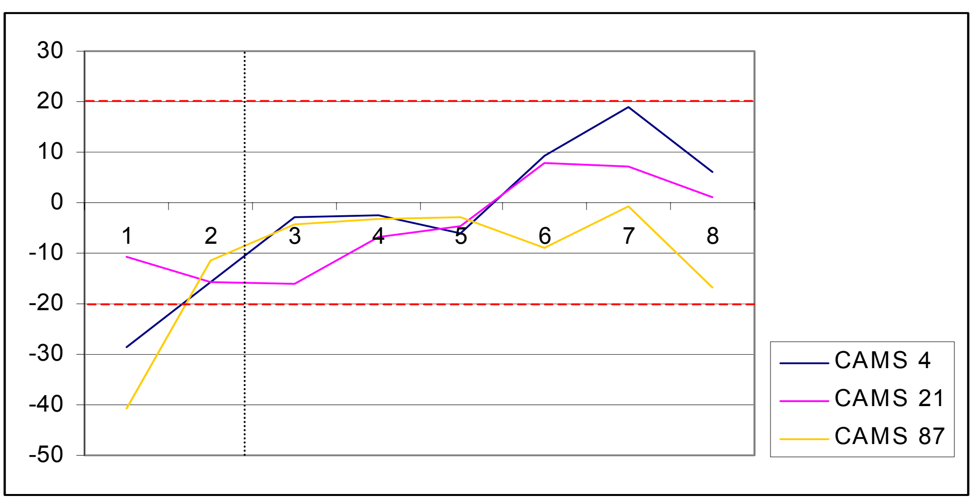
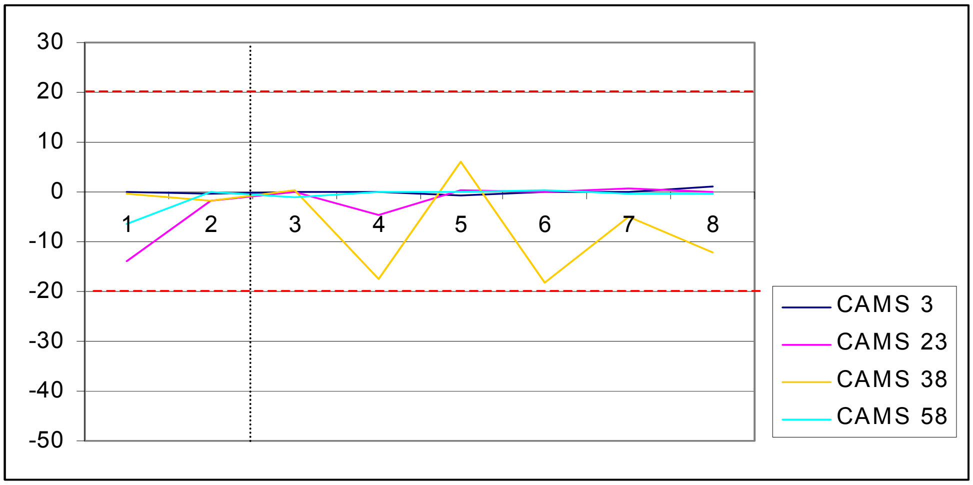
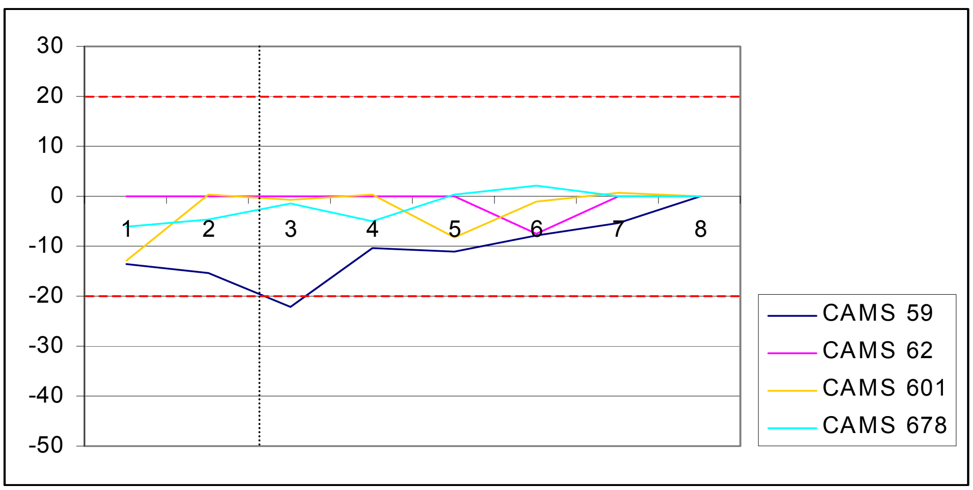


Figure E-34. Normalized Bias for Downwind, Upwind, and Coastal Monitors Calculated using Method 2, September 13- 20, 1999.

Downwind Monitors:



Upwind Monitors:



Coastal Monitors:

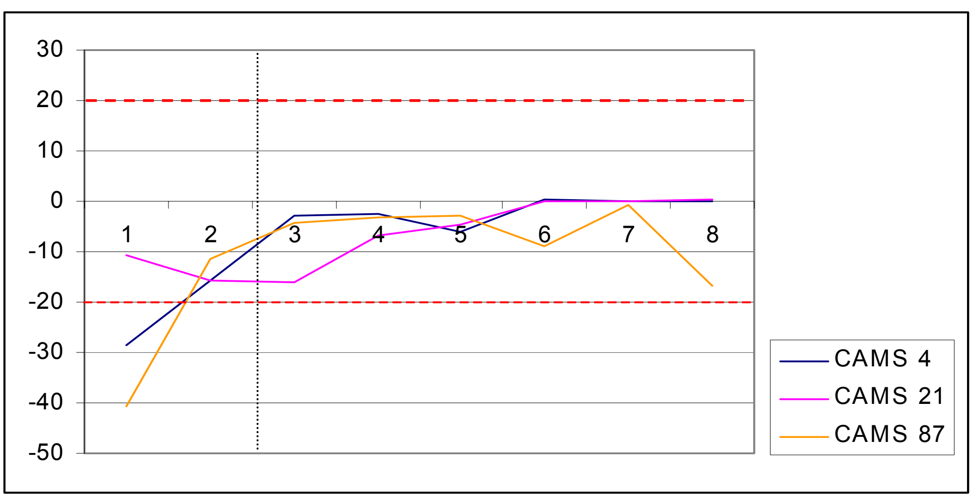
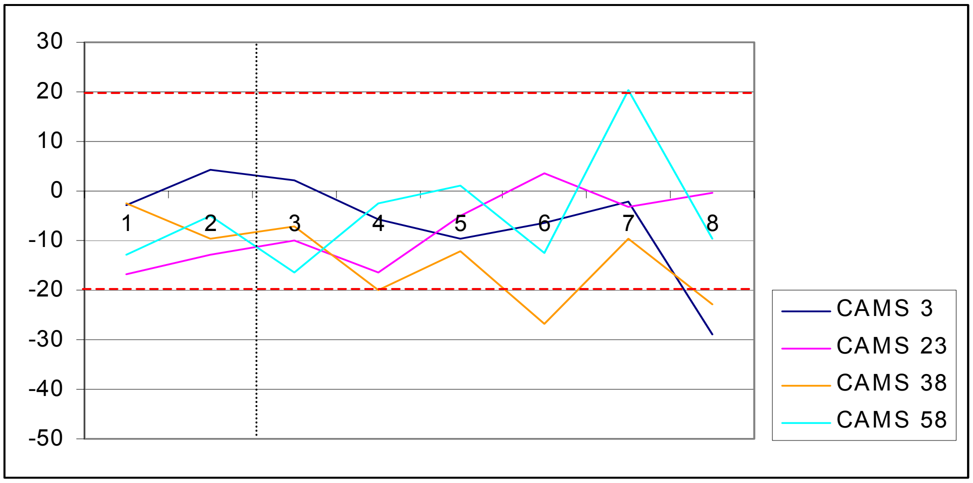
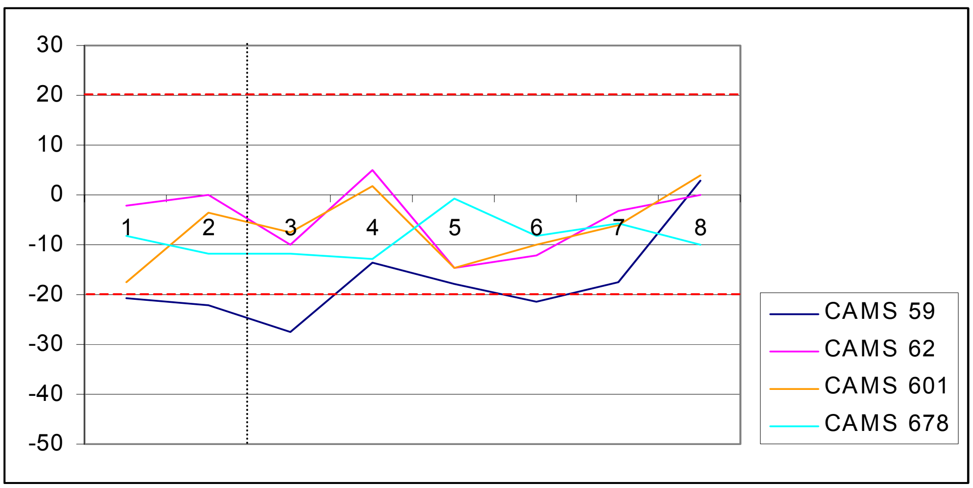


Figure E-35. Normalized Bias for Downwind, Upwind, and Coastal Monitors Calculated using Method 3, September 13- 20, 1999.

Downwind Monitors:



Upwind Monitors:



Coastal Monitors:

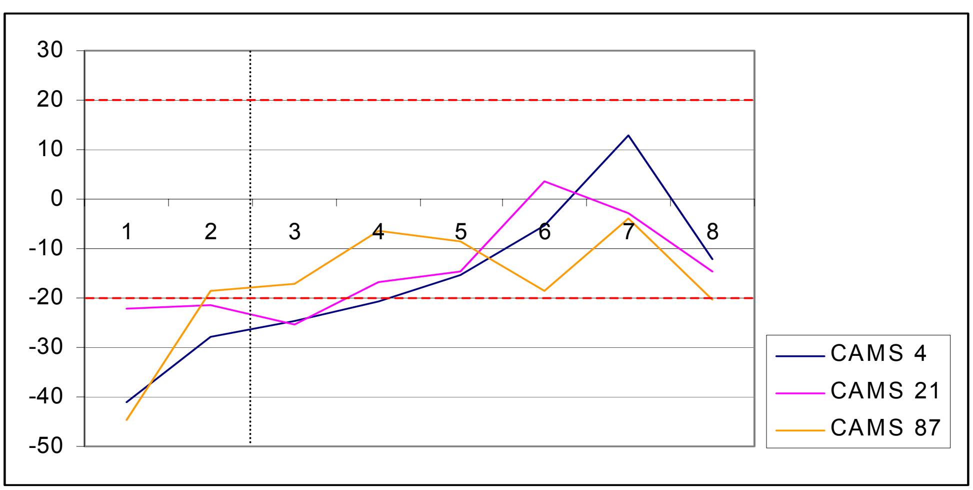
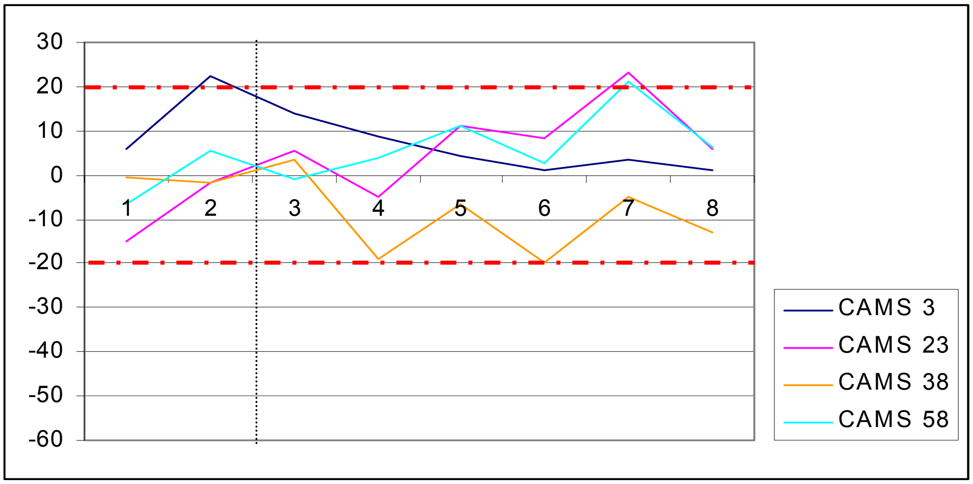
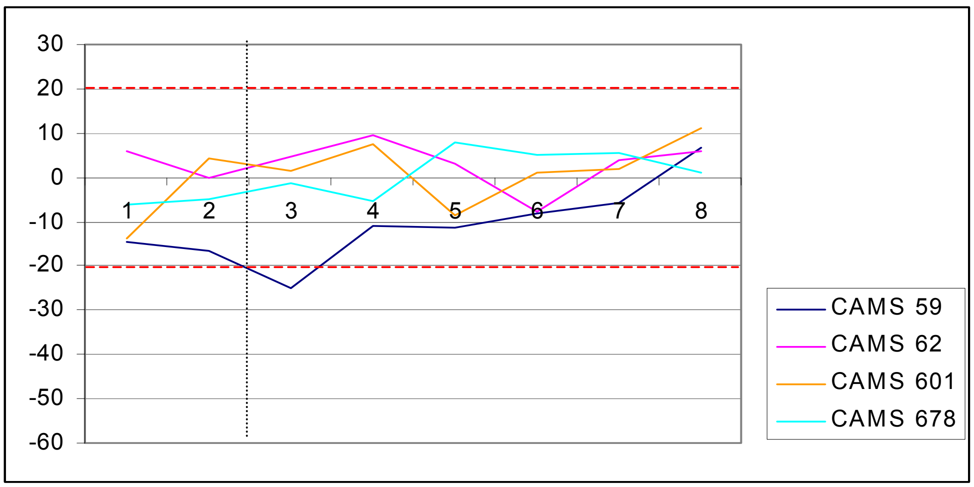


Figure E-36. Fractional Bias for Downwind, Upwind, and Coastal Monitors Calculated using Method 1, September 13- 20, 1999.

Downwind Monitors:



Upwind Monitors:



Coastal Monitors:

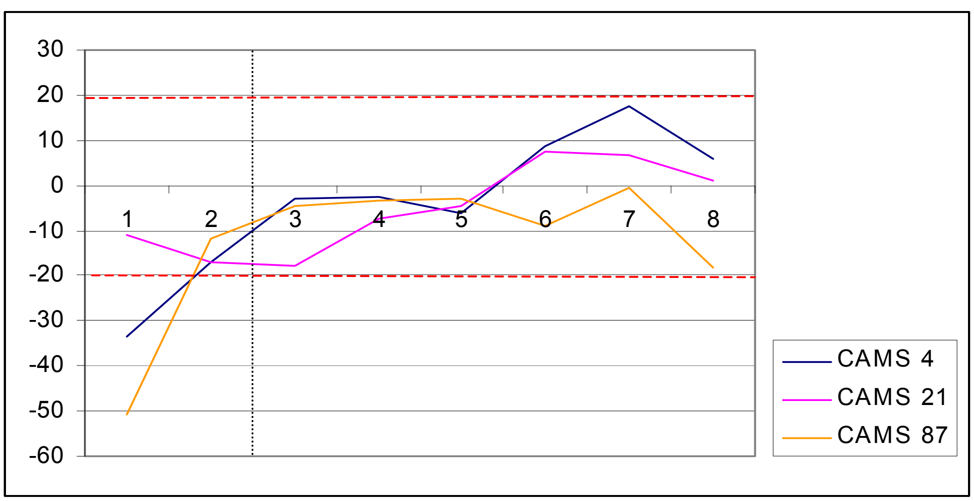
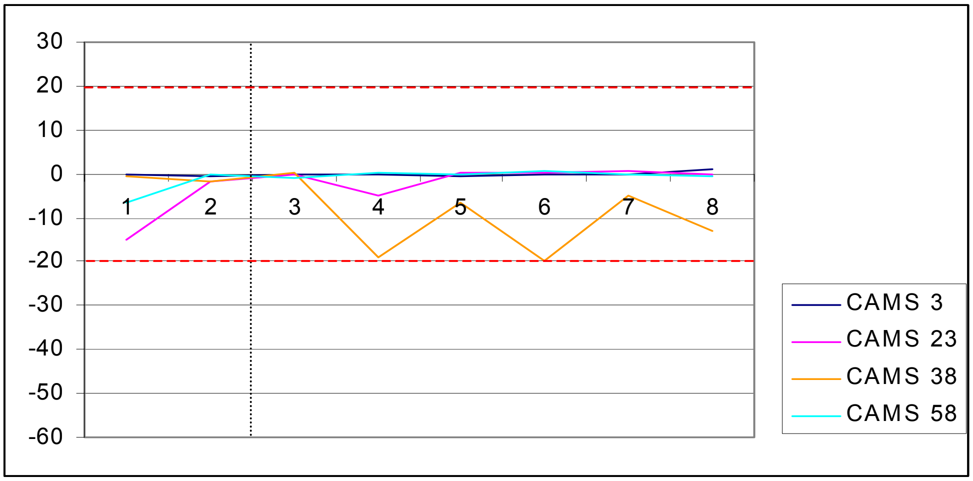
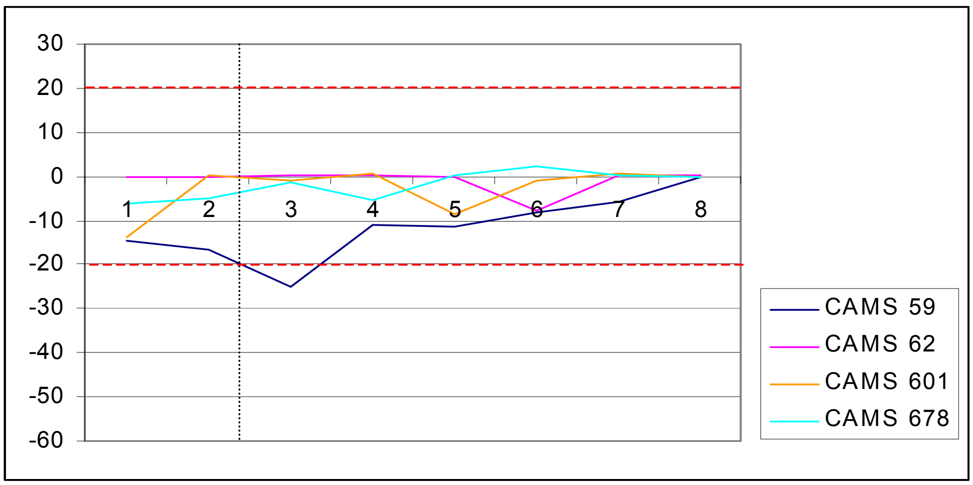


Figure E-37. Fractional Bias for Downwind, Upwind, and Coastal Monitors Calculated using Method 2, September 13- 20, 1999.

Downwind Monitors:



Upwind Monitors:



Coastal Monitors:

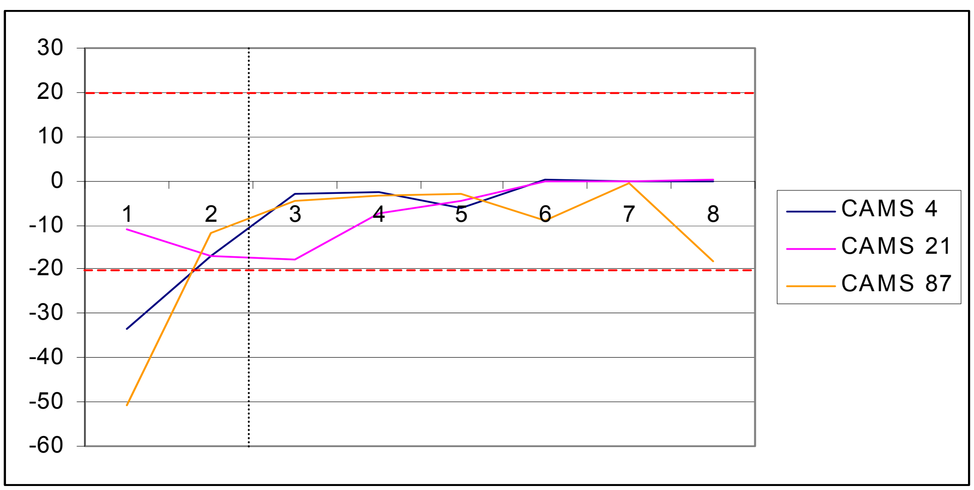
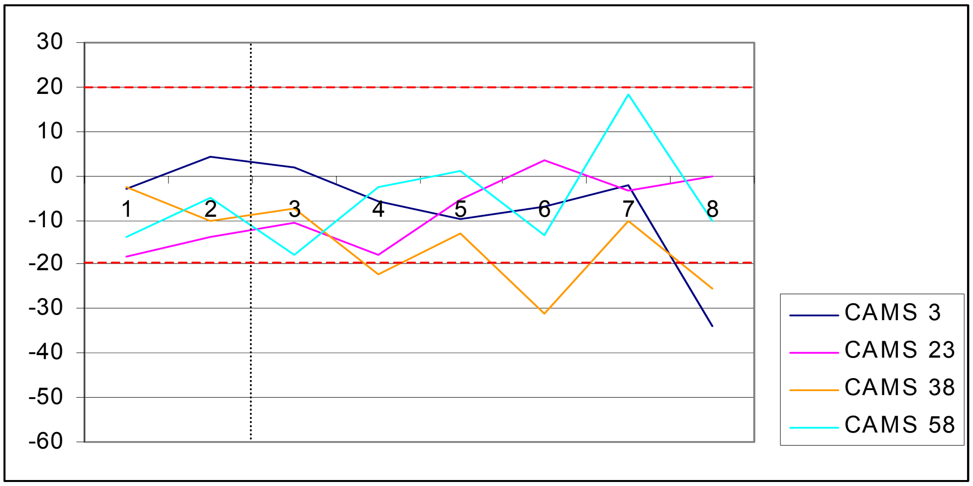
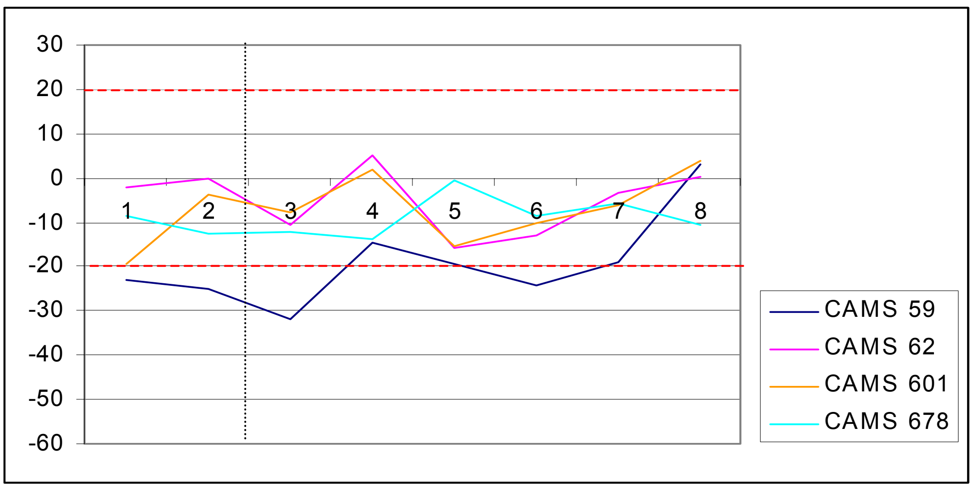


Figure E-38. Fractional Bias for Downwind, Upwind, and Coastal Monitors Calculated using Method 3, September 13- 20, 1999.

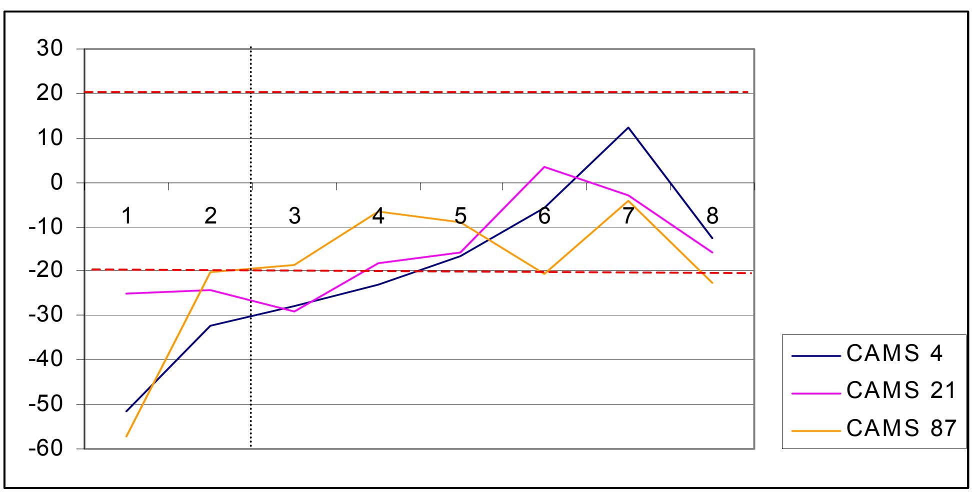
Downwind Monitors:



Upwind Monitors:



Coastal Monitors:



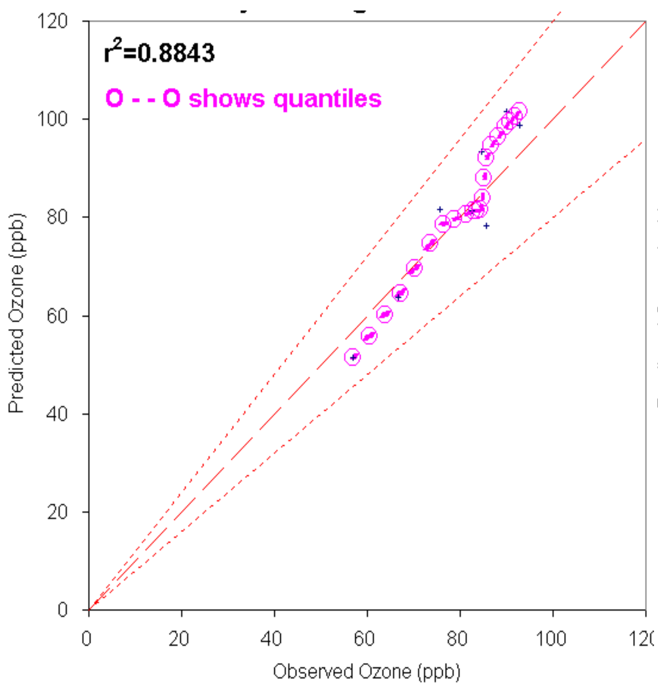
Graphic Analyses
EPA also recommends the use of graphics to evaluate model performance (EPA 1999). These recommendations include the use of time series plots, tile plots, scatter plots and Q-Q plots. Results of all four graphics analyses are provided in this section.

Scatter/Q-Q Plots
Scatter and Q-Q plots were developed using the ENVIRON software program described in the ozone metrics section. Scatter and Q-Q data are combined into single plots for each methodology. Results of scatter and Q-Q analyses using the three methodologies for data at CAMS 23, CAMS 58, and the group of Central Texas monitors are provided in figures E-39 through E-41. Eight-hour average observed/predicted data points are designated by blue "+" signs. Q-Q points are designated by magenta circles. Eight-hour scatter/Q-Q plots for other monitors and groups of monitors, as well as one-hour plots will be made available to the TCEQ and EPA on compact disc.

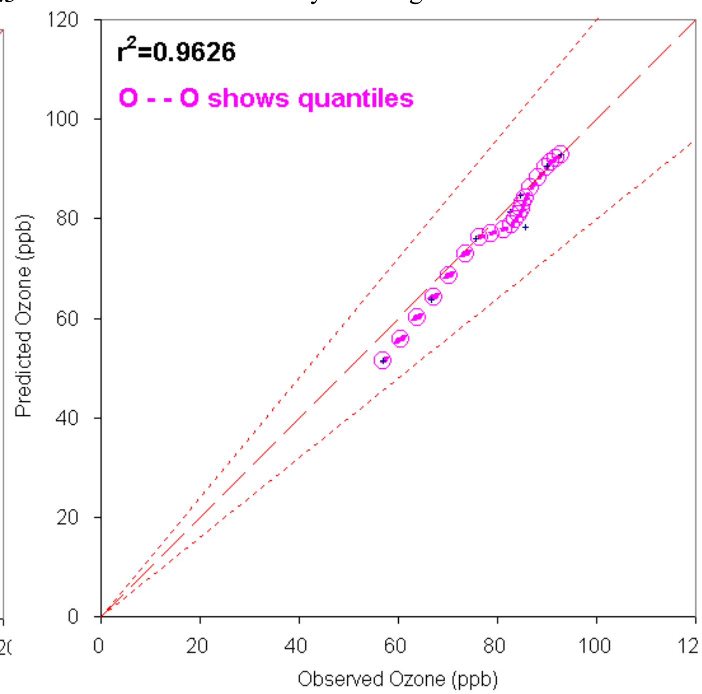
Each scatter plot demonstrates moderate to large correlation coefficients, although there are a few observed/predicted data points that fall outside the ±20% indicator lines. Quantile points on the Q-Q plots follow the 1:1 reference line fairly well for each monitor and monitor group, with no points falling outside the ±20% indicator lines. The results from these analyses indicate a high degree of correlation between the paired predicted and observed data.

Figure E-39. Scatter / Q-Q Plots for CAMS 23 Calculated using Three Methodologies.

Daily maximum 8-hour ozone near a monitor
All sites and all days. Subregion = AACOG CAMS 23



Nearest daily maximum 8-hour ozone.
All sites and all days. Subregion = AACOG CAMS 23



Daily maximum 8-our ozone at monitor.
All sites and all days. Subregion = AACOG CAMS 23

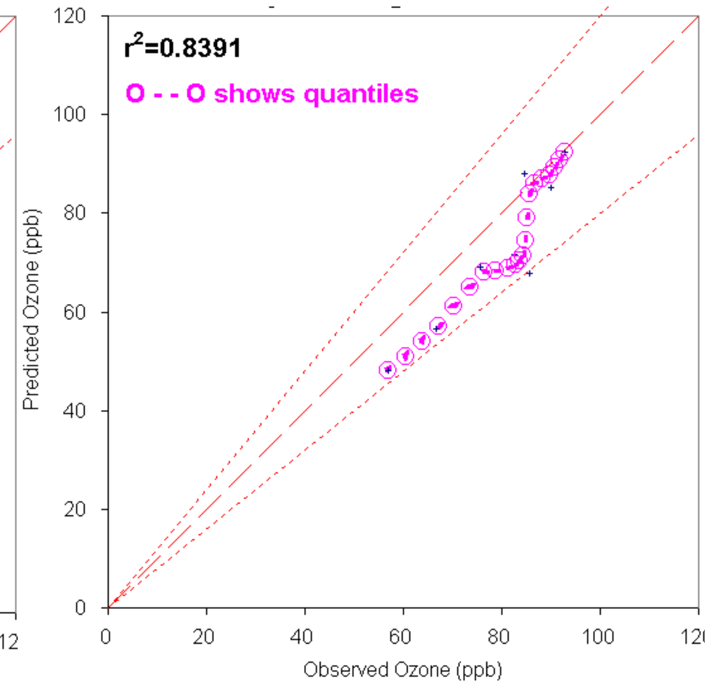


Figure E-40. Scatter / Q-Q Plots for CAMS 58 Calculated using Three Methodologies.

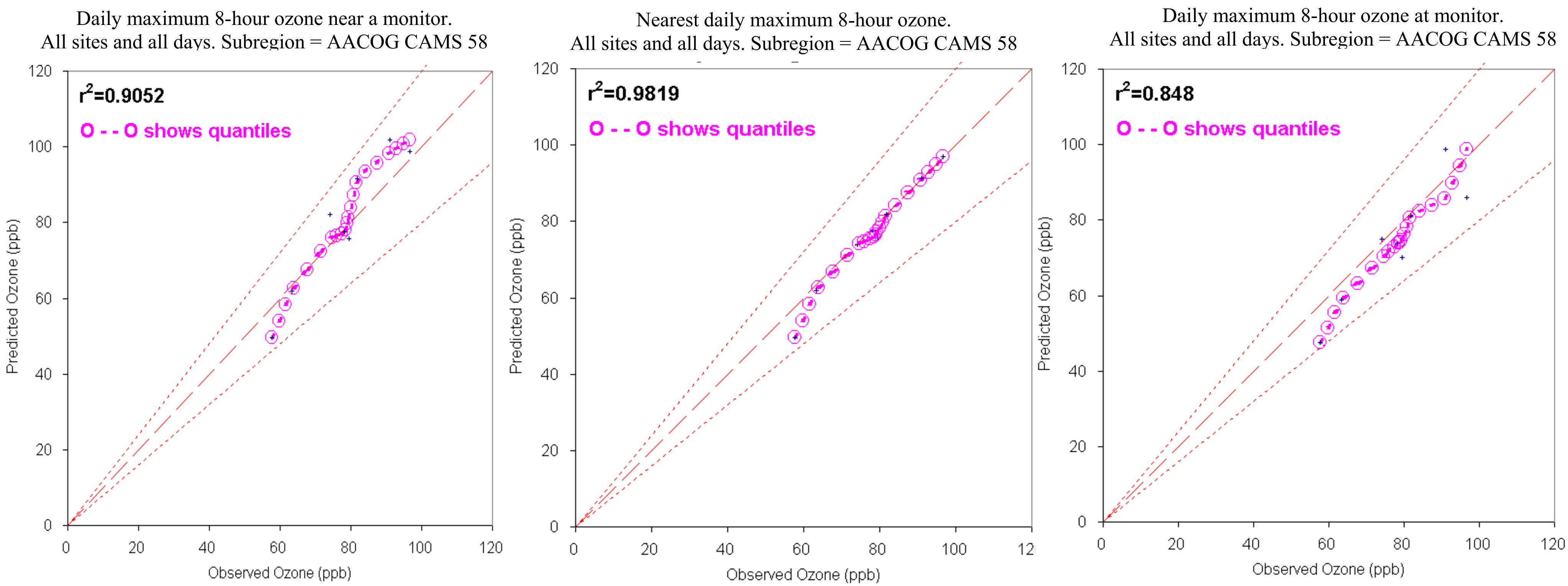
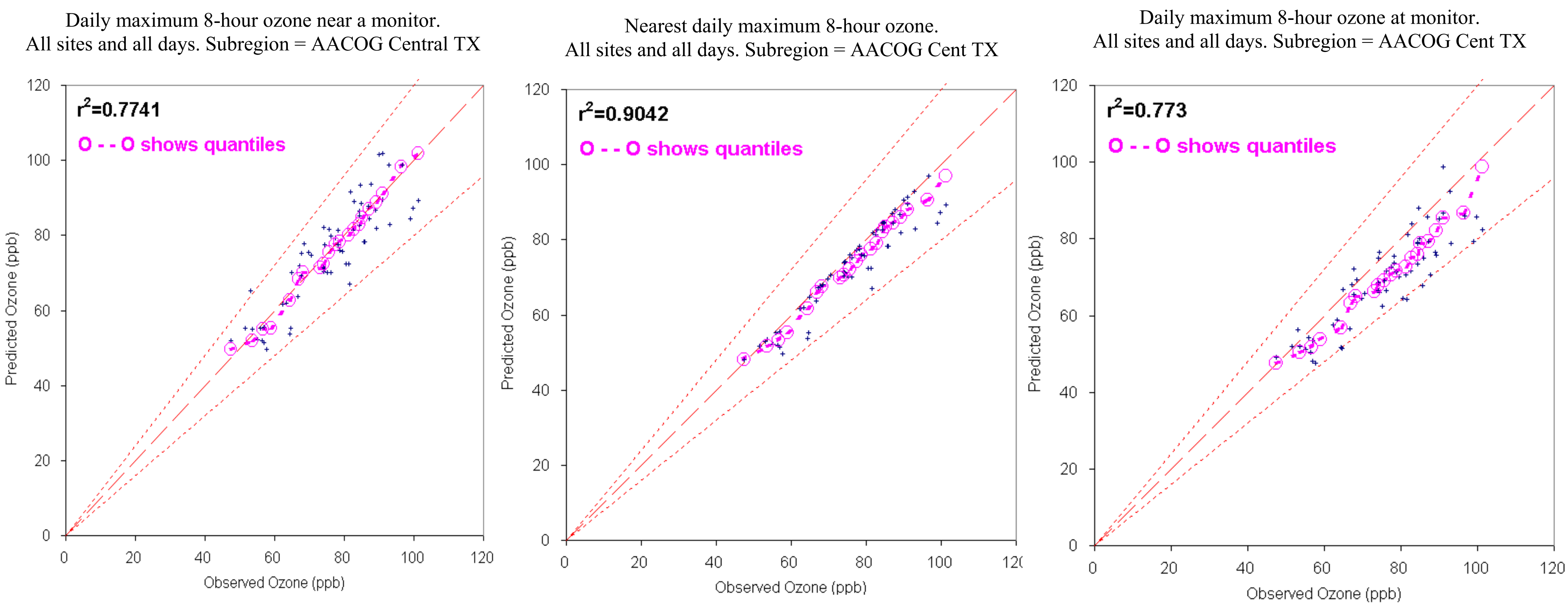


Figure E-41. Scatter / Q-Q Plots for the Eight Central Texas Monitors (CAMS 3, 23, 38, 58, 59, 62, 601, 678) Calculated using Three Methodologies.



Tile Plots
Tile plots provide an indication of where the model is or isn't performing correctly. These plots are visual representations of the model's predictions and provide such information as when and where the model predicts urban plumes. The following tile plots (figures E-42 through E-47) represent the 8-hour daily maximum concentrations within the modeling domain for each day of the primary episode.

As demonstrated by these plots, urban plumes are replicated well, both in terms of intensity and spatial allocation. Peak ozone concentrations are predicted downwind of city centers and major point sources in these tile plots.

Figure E-42. Predicted Daily Maximum 8-hour Ozone Concentrations within the 4-km Subdomain for Wednesday, September 15, 1999.

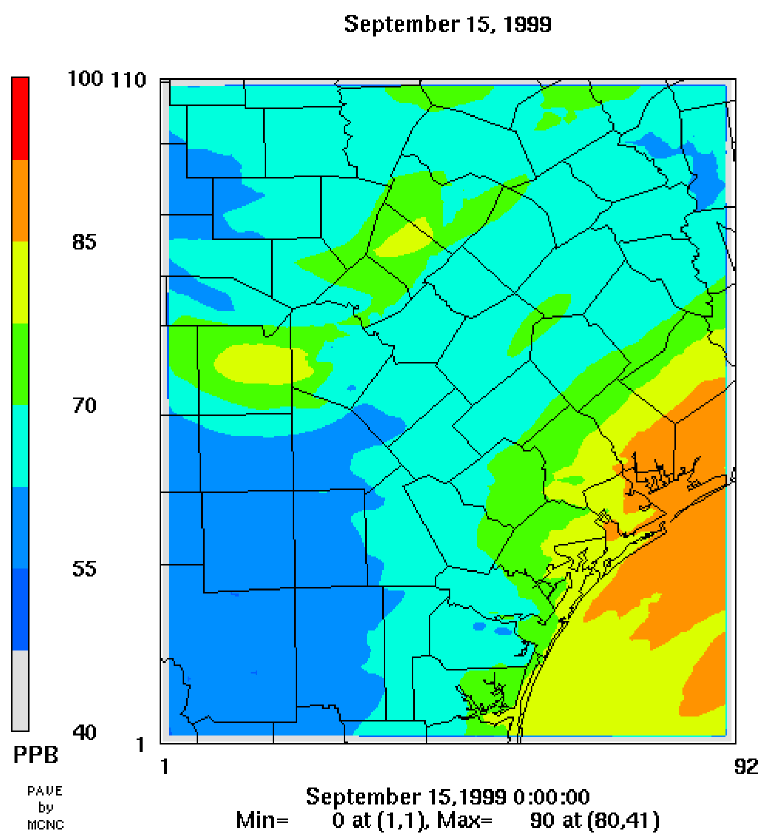


Figure E-43. Predicted Daily Maximum 8-hour Ozone Concentrations within the 4-km Subdomain for Thursday, September 16, 1999.

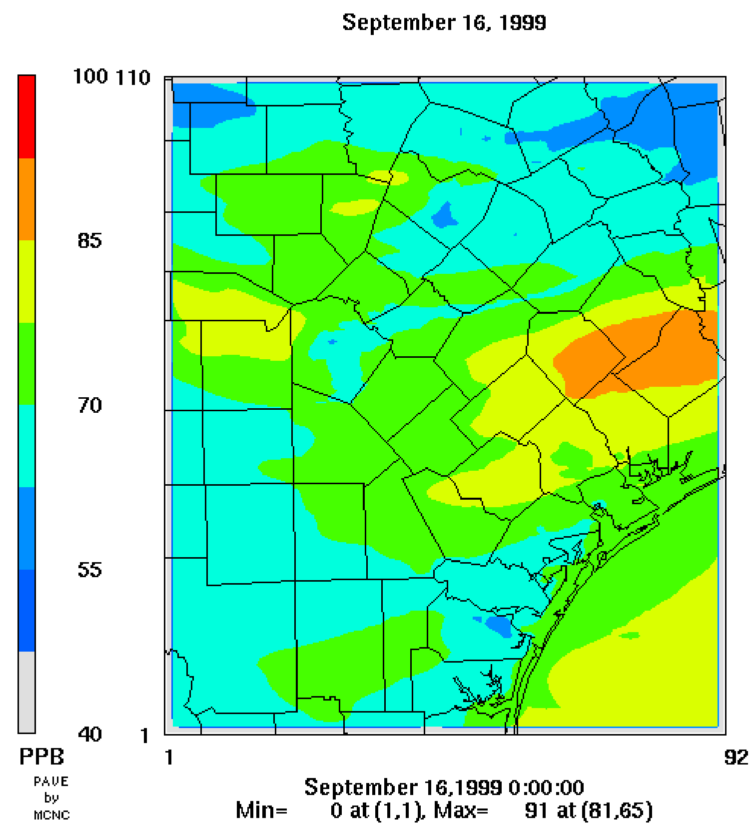


Figure E-44. Predicted Daily Maximum 8-hour Ozone Concentrations within the 4-km Subdomain for Friday, September 17, 1999.

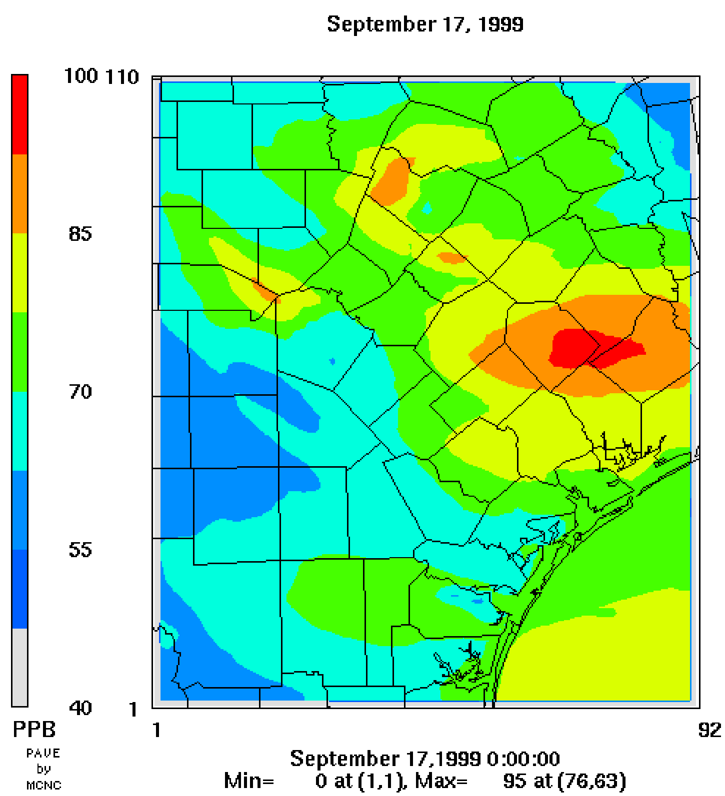


Figure E-45. Predicted Daily Maximum 8-hour Ozone Concentrations within the 4-km Subdomain for Saturday, September 18, 1999.

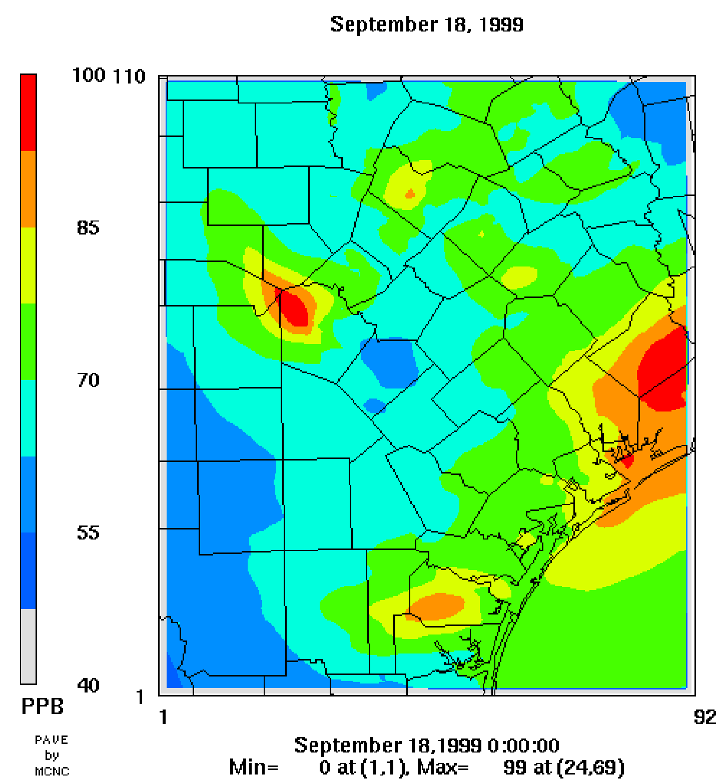


Figure E-46. Predicted Daily Maximum 8-hour Ozone Concentrations within the 4-km Subdomain for Sunday, September 19, 1999.

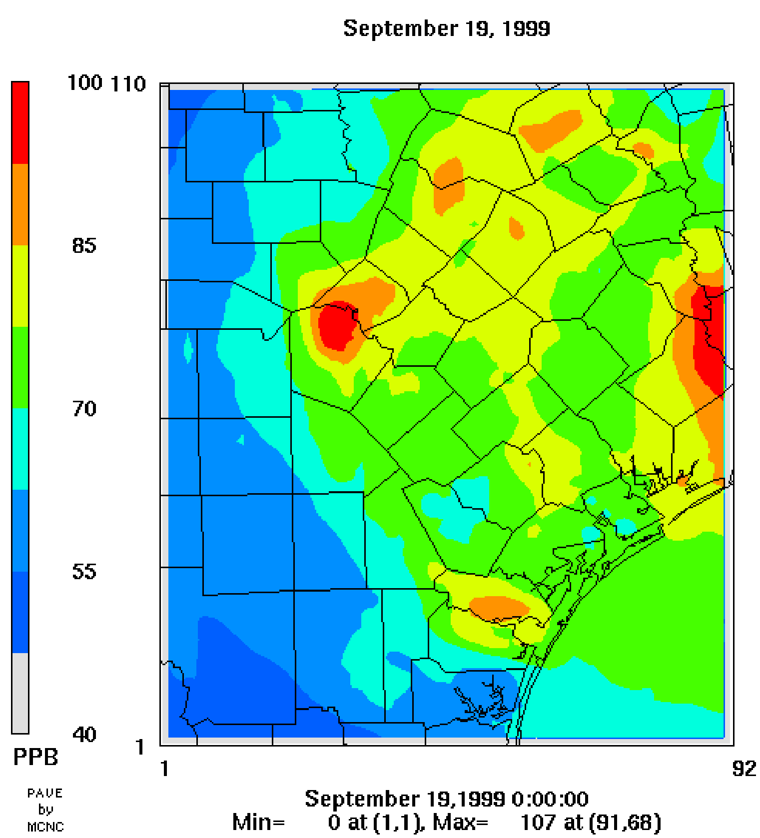
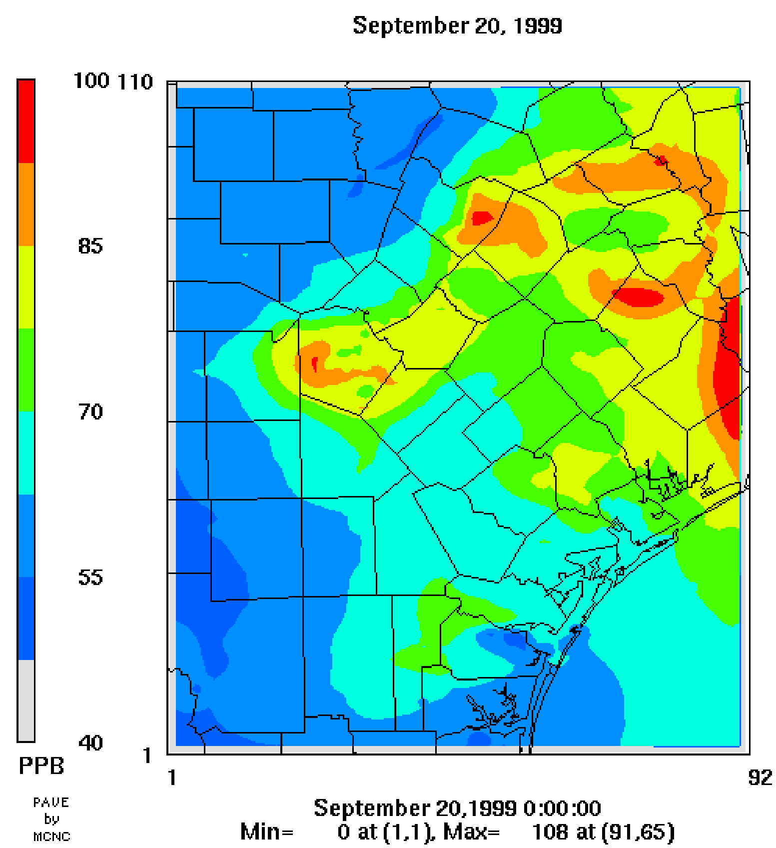


Figure E-47. Predicted Daily Maximum 8-hour Ozone Concentrations within the 4-km Subdomain for Monday, September 20, 1999.



Diagnostic Evaluations

Diagnostic tests are conducted throughout model development to assist with identifying and troubleshooting performance problems. An important method of conducting diagnostic evaluations involves the use of sensitivity tests. These tests are conducted by perturbing various types of model input. For example, sensitivity tests were conducted on the 1999 episode by altering the model's boundary conditions. As a result of these tests, some boundary conditions were modified from default values to measurements collected during studies of background concentrations (described in appendix B).

Sensitivity tests may also be used to evaluate the base and future case runs to ensure the model responds appropriately to changes in emissions inputs and to estimate the impact of control strategies. This section presents the results of conducting sensitivity runs on the 1999 base case as a means of assessing the responsiveness of the model and providing an indication of which type of emissions reductions may be most useful for improving air quality in the San Antonio region.

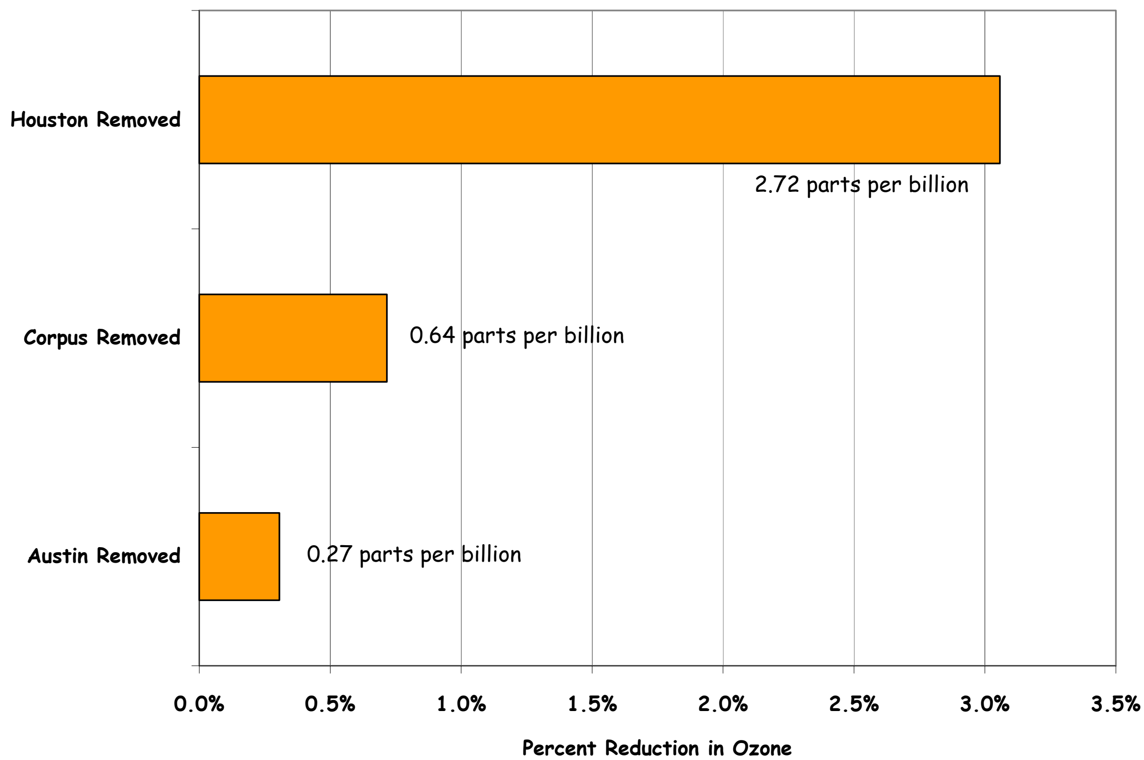
<u>Zero-out Runs: Urban Areas</u>

One sensitivity evaluation involved removing the anthropogenic VOC and NOx emissions for the 8-county Houston area from the photochemical model. Similarly, two other sensitivity runs were conducted by removing anthropogenic precursor emissions for the 5-county Austin area and 2-county Corpus Christi area from the model. All three of these urban areas were upwind of the SAER on at least one September 1999 episode day.

The results of removing anthropogenic emissions were averaged over the 6-day primary episode period (September 15 – 20th) for each of the three sensitivity runs. Figure E-48 provides the estimated average reductions in ozone concentrations within the SAER after removing the anthropogenic emissions for Austin, Corpus Christi, and Houston from the model. As indicated, removing Houston's precursor emissions had the greatest impact on estimated ozone concentrations in the San Antonio region (2.72 ppb), followed by Corpus Christi (0.64 ppb), and Austin (0.27 ppb).

These outcomes are consistent with the meteorological conditions that existed during the episode. Although Austin is closer in proximity to San Antonio, back trajectory information indicates that wind parcels traveled through Houston and Corpus Christi more often during the September 1999 episode than through Austin. In addition, Houston is a much larger source of precursor emissions than either Corpus Christi or Austin.

Figure E-48. Predicted Reduction in Ozone Concentrations (%) in the SAER after Removing Austin, Corpus Christi, and Houston Anthropogenic NOx and VOC Emissions from the Photochemical Model. (Average reductions for September 15 – 20, 1999).



Incremental Removal of VOC and NOx Precursors
Across-the-board sensitivity runs were conducted by removing 25%, 50%, 75%, and 100% of the local (4-county SAER) NOx emissions, VOC emissions, and combinations of the two, from the CAMx Run 17b model. Figures E-49 through E-54 provide the results of the across-the-board reduction runs for each day of the primary episode. These graphs provide the model's ozone concentration predictions at CAMS 23, the controlling monitor, as the result of reducing local precursor emissions, compared to the monitor's design value.

Due to time constraints, VOC/NOx reduction analyses were not conducted on the final run, CAMx Run 18. However, several precursor sensitivity runs were conducted on a prior version of the September 1999 model, CAMx Run 17b. The primary difference between CAMx Run 17b and CAMx Run 18, for the 1999 base cases,[4] was the use of a refined MOBILE6 on-road EI in the latter model, as described in section 3.4 of the Executive Summary. Rerunning all the sensitivity tests again on Run 18 would have added an enormous amount of work. Based upon experience, it was assumed that the

[4] The 2007 projection developed from CAMx Run 18a incorporates a refined regional EI (described in Section 3.6 of the Executive Summary); however, the regional EIs for Runs 17b and 18a 1999 base cases are identical.

general findings and directional guidance determined from previous runs would remain stable with relatively small emissions adjustments.

As indicated by the VOC/NOx sensitivity runs, reductions of NOx, VOC, or a combination of NOx and VOC effectively reduced ozone concentrations at the 25% reduction level on most episode days. An exception occurs on September 17th, when the model predicts a NOx reduction disbenefit as the result of removing 25% and 50% of the anthropogenic SAER emissions. Because of the NOx reduction disbenefit predicted on the 17th and 20th, reducing VOC emissions alone, not a combination of VOC and NOx reductions, was the most effective method of reducing ozone concentrations on those episode days. Another point that is evident from these analyses is that, in general, VOC reductions were more effective than NOx reductions over the range of controls required to demonstrate attainment.

Figure E-49. Predicted Ozone Concentrations at CAMS 23 after Removing Local (4-county SAER) NOx and VOC Emissions from Simulation 17b, September 15, 1999.

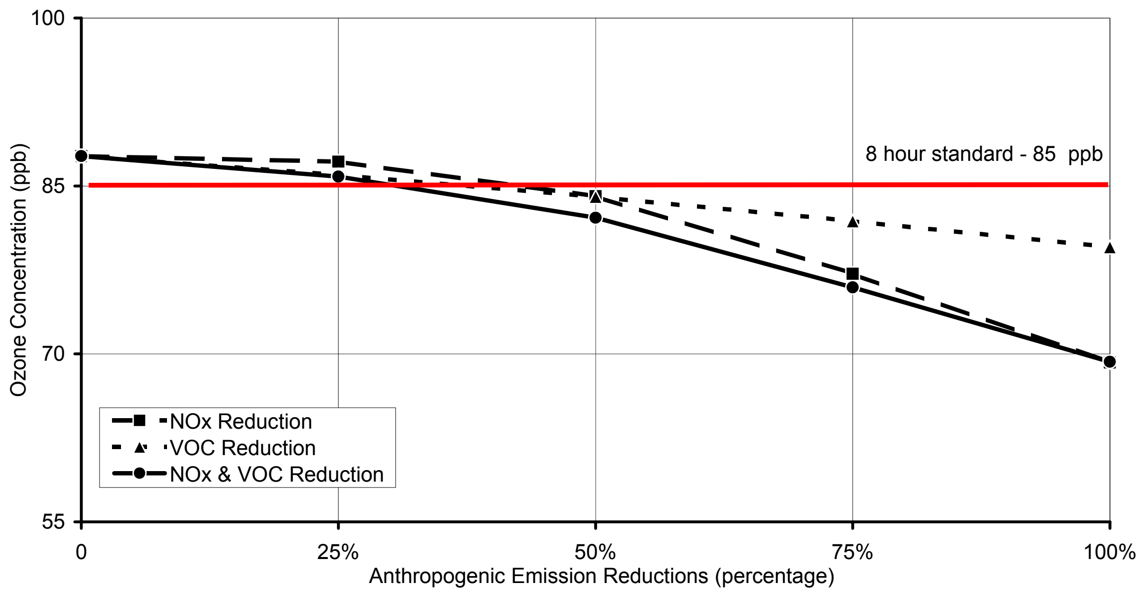


Figure E-50. Predicted Ozone Concentrations at CAMS 23 after Removing Local (4-county SAER) NOx and VOC Emissions from Simulation 17b, September 16, 1999.

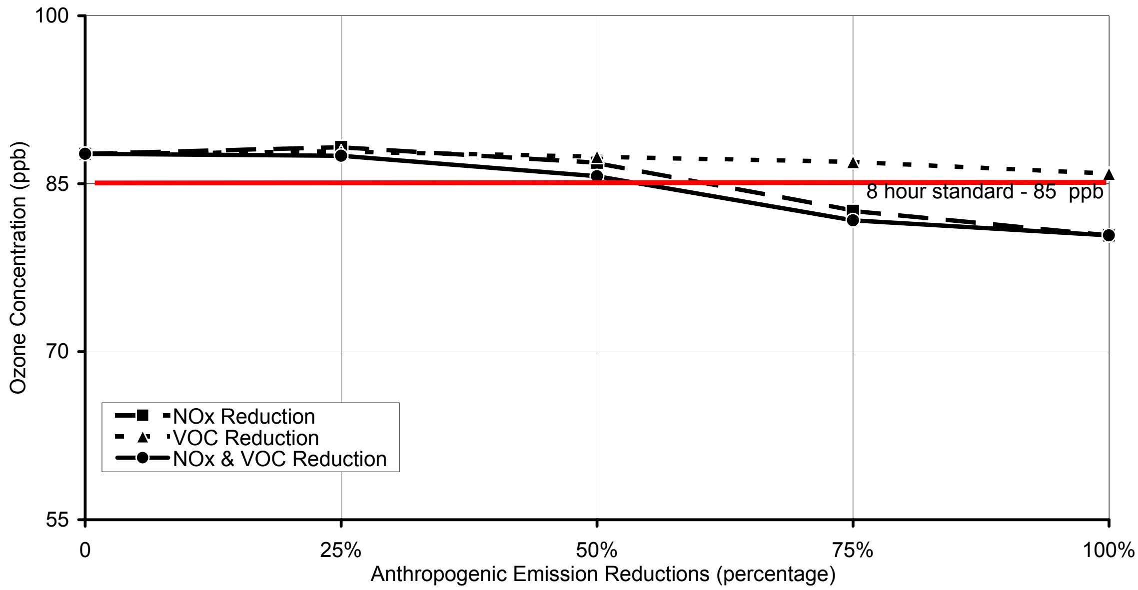


Figure E-51. Predicted Ozone Concentrations at CAMS 23 after Removing Local (4-county SAER) NOx and VOC Emissions from Simulation 17b, September 17, 1999.

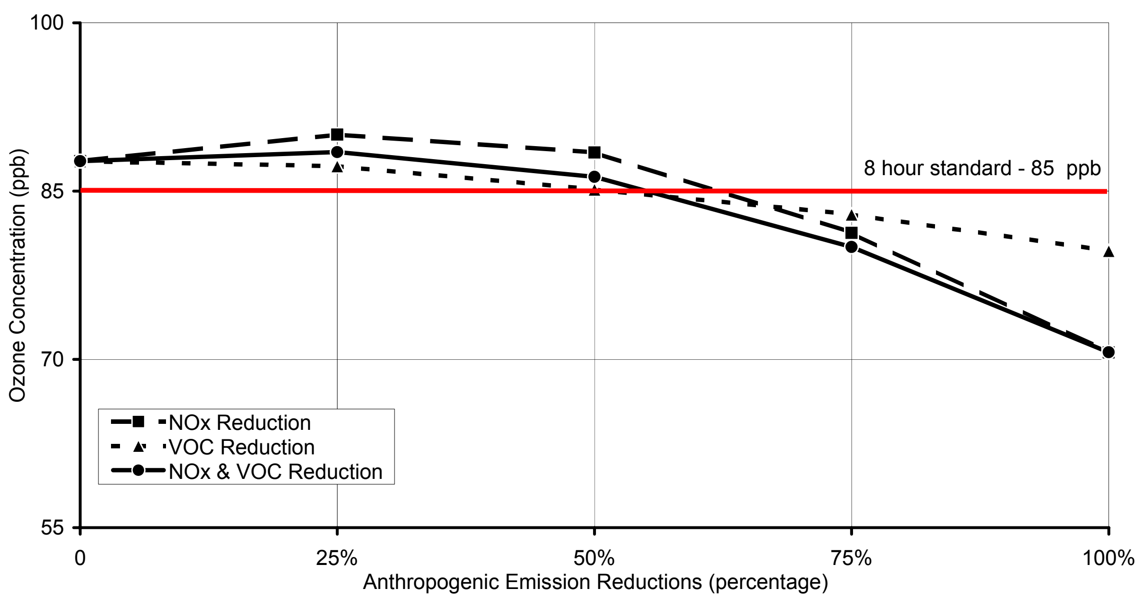


Figure E-52. Predicted Ozone Concentrations at CAMS 23 after Removing Local NOx and VOC Emissions from Simulation 17b, September 18, 1999.

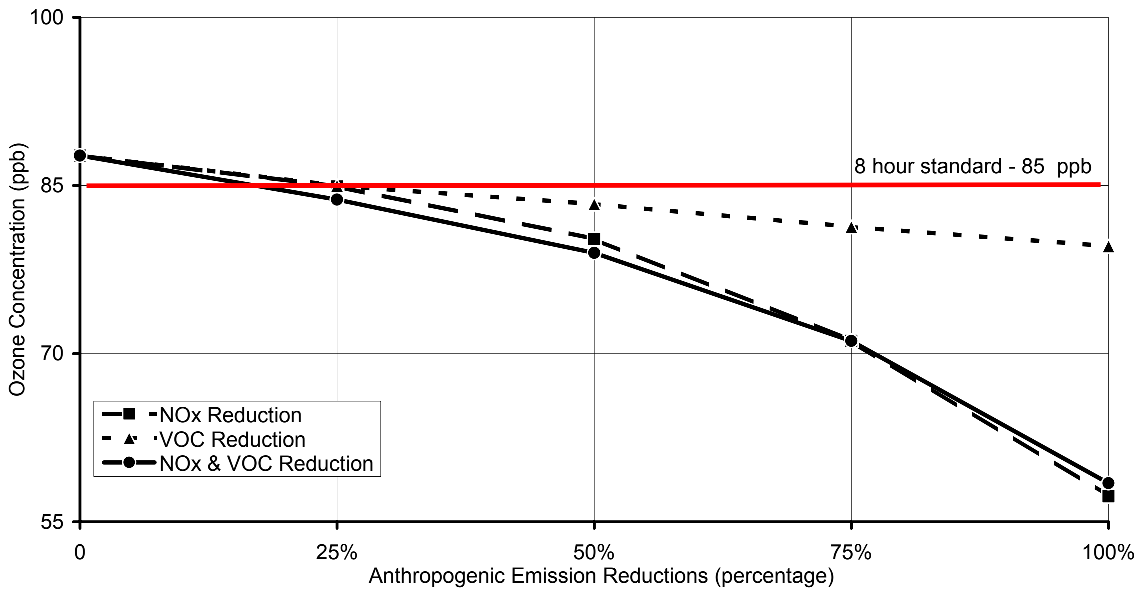


Figure E-53. Predicted Ozone Concentrations at CAMS 23 after Removing Local NOx and VOC Emissions from Simulation 17b, September 19, 1999.

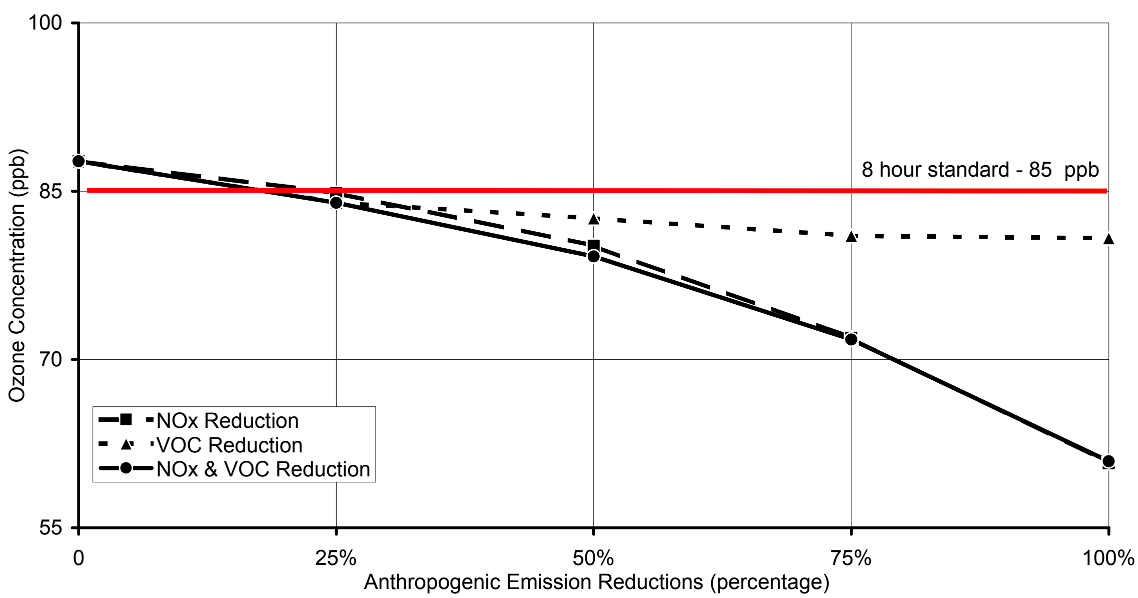
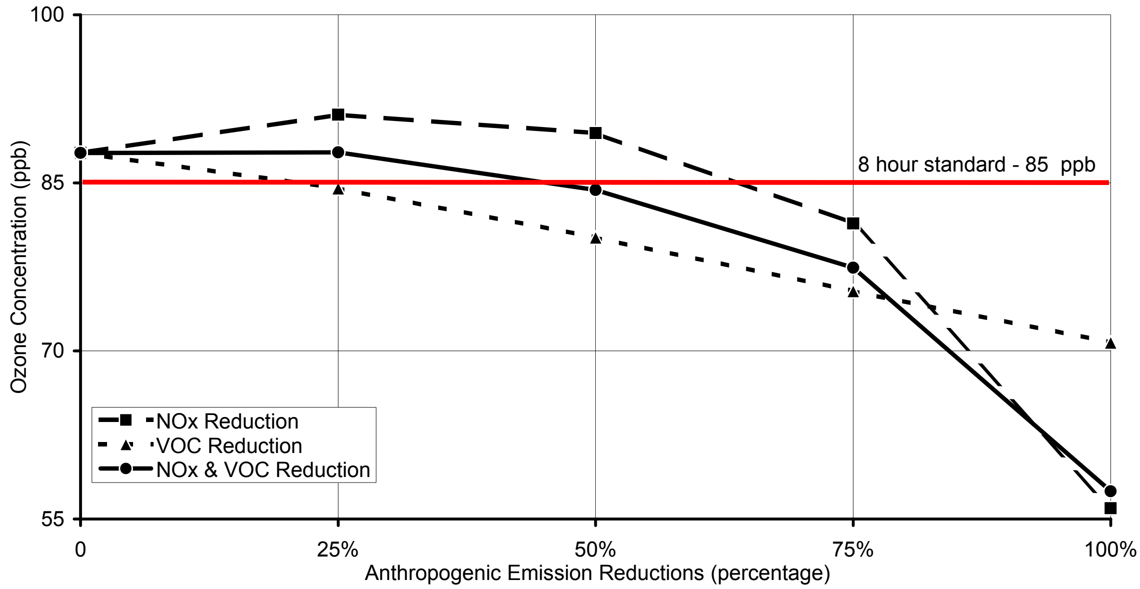


Figure E-54. Predicted Ozone Concentrations at CAMS 23 after Removing Local NOx and VOC Emissions from Simulation 17b, September 20, 1999.



COMPARISONS BETWEEN UT AUSTIN AND AACGO 1999 BASE CASES

Although the original September 1999 model was developed by ENVIRON and refined through a collaboration between ENVIRON and UT Austin (meteorological model and air quality input refinements), the model was eventually provided to the NNA partners (or their contractors) for further modifications. These modifications included refinement of the emissions inventory inputs, development of the future case, and clean air strategy analyses. Because the model was modified by more than one agency during this process, there was a concern that the various agencies' models would become dissimilar and provide different predictions for the base case, future case, and control strategy runs.

A great amount of effort was spent ensuring that the Austin and San Antonio base and future cases contained identical input. Often this involved discussions between the two agencies, as well as TCEQ, regarding the most appropriate EI data for local and regional areas. Discrepancies in emissions inputs were corrected prior to the final AACOG run and the final UT run.

An analysis was conducted by AACOG staff to determine any differences between the final 1999 run refined by UT Austin and the final run refined by AACOG, based on ozone predictions near two Austin monitors. The results of these analyses are provided in table E-52. The table lists peak predictions within the 7x7 array of cells near the Murchison and Audubon monitors for the AACOG (highlighted in yellow) and UT 1999 base cases.

As shown, the differences between predictions by AACOG's final run (labeled 1999_sos.f) and UT's final run (labeled 1999_v3) are insignificant. With regards to the Murchison monitor, the average difference (six episode days) in ozone concentrations between the two 1999 base cases was 0.00 ppb, while the average difference at the

Audubon monitor was 0.05 ppb. The 2007 future cases developed by AACOG and UT Austin were similarly compared. These comparisons are provided in appendix G.

The performance of the September 1999 photochemical model was thoroughly analyzed and tested by AACOG staff, both in terms of 1-hour and 8-hour predictions, using a variety of EPA-recommended performance evaluations. Because the model is being used by other Texas NNA regions, performance analyses have been conducted by other agencies as well. Each has concluded that the September 1999 model meets EPA-acceptance criteria for attainment demonstration modeling. Furthermore, comparisons between the 1999 base case refined by AACOG and the 1999 base case refined by UT Austin provides additional, independent verification of the quality of the model in terms of performance.

Table E-52. Comparison of Predicted Peak 8-hour Concentrations for Final UT and AACOG Base Case Runs.

Monitor	UT **1999_v3**	AACOG **1999_sos.f**	Average Difference	**Days**	Date
MURCHISON	84.6	84.6	0.00	6	9/15 – 9/20
AUDU	81	80.9	0.05	6	9/15 – 9/20
Monitor	UT **1999_v3**	AACOG **1999_sos.f**	Daily Difference	Days	Date
MURC	77.8	77.8	0.0	1	9/15
MURC	75.5	75.4	0.1	1	9/16
MURC	86.8	86.7	0.1	1	9/17
MURC	84.5	84.4	0.1	1	9/18
MURC	89.6	89.7	-0.1	1	9/19
MURC	93.6	93.6	0.0	1	9/20
AUDU	76.2	76.1	0.1	1	9/15
AUDU	78.2	78.2	0.0	1	9/16
AUDU	87.4	87.4	0.0	1	9/17
AUDU	84.5	84.4	0.1	1	9/18
AUDU	89.4	89.5	-0.1	1	9/19
AUDU	70.1	70.2	-0.1	1	9/20

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